WP6- NA6: WP "Integration, outreach, and sustainability"
Deliverable D6.2: Report on steps needed to implement a sustainable network of type ESFRI

ACTRIS ROADMAP

Towards world-class European Research Infrastructure (ESFRI)

This Roadmap, dated on 25.June. 2012, is the first version of the agreed ACTRIS ROADMAP. This document is the EU-FP7- ACTRIS-I3 WP-6 deliverable and has been written and edited by WP-6 lead institute, University of Helsinki; Dr. Hanna Lappalainen, Prof. Markku Kulmala. The content is based on the vision and comments received from the EU-FP7-ACTRIS-I3 project Coordinator Dr. Gelsomina Pappalardo (CNR-IMAA) and Co-Coordinator Dr. Paolo Laj (CNRS-LGGE) , ACTRIS-I3- Steering Group and Dr. Sanna Sorvari, University of Helsinki/ FMI.

Starting from 1.July.2012 this document is the first version of a living-document will be updated when needed.

Contents

Summary

The ACTRIS-I3 "Aerosols, Clouds, and Trace gases Research InfraStructure Network" project is an European Commission FP-7-Project aiming at integrating European ground-based stations equipped with advanced atmospheric probing instrumentation for aerosols, clouds, and short-lived gas-phase species. ACTRIS will be active for a period of 4 years, from 1st April 2011 to 30th March 2015. The project is coordinated by CNR (Italy) and CNRS (France) and has 29 partners. ACTRIS consortium represents 35 infrastructures in 24 European countries; furthermore, more than 60 sites are reporting ACTRIS labeled data.

The ACTRIS-I3-project is an essential pillar of the EU ground-based observing system that provides the long-term observations information required to understand current variability of the atmospheric aerosol components and better predict their impact on climate and air quality in a changing climate. ACTRIS provides the key information required to develop the proper level of understanding on the evolution of the aerosol cycle, including attribution of sources and sinks, assessment of climate forcing and possible climate feedbacks. ACTRIS is developed in support of the EU research initiatives and designed and operated as an essential support of operational networks for long-term air quality monitoring and of the on-going development of atmospheric services within GMES. ACTRIS RI is supporting and complementing aircraft and satellite observations and has the important role in validation, integration, full exploitation of remote sensing data. The ACTRIS infrastructure will deliver critical long-term datasets for the climate and air quality research including evaluation of weather forecast and climate models.

The strategic focus of ACTRIS is to ensure the long-term continuation of advanced measurements on aerosols, clouds and reactive gases in Europe in a coordinated and cost-efficient way. Thus the ACTRIS framework is focused to be part of the European Union research infrastructure landscape ensuring Europe's competitiveness in "frontier" research. US has just recently (Feb 2012) announced initiative (Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants) to reduce the short-lived climate pollutants (black carbon, methane, hydrofluorocarbons HFCs) in the atmosphere. This action provides pressure to establish the ACTRIS typed long-term operative RI also in Europe.

The ESFRI's (European Strategy Forum on Research Infrastructures) Roadmap is currently identifying the pan-European Research Infrastructures (RIs) and their services for European research communities for the next 10 to 20 years. ACTRIS-I3-project RI aims to be listed under the European world class research infrastructures in the ESFRI (Environment cluster) roadmap. Via ESFRI status, ACTRIS will be part of the environmental ESFRI RI landscape and provide important atmospheric data and knowledge for the whole environment cluster. As a part of the process towards a long-term, world class European RI, the ACTRIS RI needs to be listed also in the National research infrastructures Roadmaps. National RI status is needed for earmarking of national budgets for participating in a common pan-European effort. After having ESFRI and national RI status the ACTRIS RI is targeted for the FP preparatory phase project (4 yrs) to prepare and construct the future ACTRIS RI and to set-up the ACTRIS legal entity, most possible under the model of an ERIC - European Research Infrastructure Consortium. The estimated schedule of the process from the ACTRIS-I3 project to ACTRIS world-class European RI in operation would be in 8 years. 1) EU-FP-7-ACTRIS-I3 years 2011-2015, 2) National ACTRIS Roadmap Statuses established by 2015, 3) ACTRIS-ESFRI-Roadmap-proposal submission and status in the next ESFRI Roadmap update process (approx. 2014/15**)**, followed 4) ACTRIS-RI pan-European Infrastructure Preparatory Phase, 4 years with last two years for RI construction, and 5) Start of operation in 2019.

1. Status of Research Infrastructure actions on key atmospheric components

1.1 European Research Infrastructure of key atmospheric components

The new organization of the European research infrastructures (RI) towards world class research facilities and data services is under way. The European Union has set the roadmap, how the European research communities should organize and project their research facilities, data collection and services for a long-term, high-quality operative activity. As a part of building the European Union research area and to ensure Europe's competitiveness in "frontier" research EU is listing the European world class research infrastructures in the European Strategy Forum on Research Infrastructures (ESFRI) roadmap. The ESFRI's Roadmap identifies and determines the pan-European Research Infrastructures (RIs) and their services for European research communities for the next 10 to 20 years. The successful ESFRI projects will construct their services towards operational systems in a process, which will go on for four to five years. To step in the process towards European world class infrastructure requires a well established observation network with harmonized services in the research area of interest. The successful completion of the EU-FP-7 Infrastructure Projects demonstrates the type of readiness for the RI process.

One of the key areas of European interest in the ESFRI process is the Environment segment including climate and air quality monitoring. The development of the greenhouses gases research infrastructure, the integrated carbon observations (ICOS) is already in the end of its preparatory phase and will soon establish its long-term operational observation and services system. However, at present the roadmap is lacking a coordinated European RI to sustain simultaneous observation of aerosol and their interaction with the other atmospheric constituents, the trace gases and clouds. Aerosols, clouds, greenhouse and trace gases are the key atmospheric components related to processes and feedback mechanisms of Earth radiation balance, climate change and air quality. Contrary to greenhouse gases, radiative forcing by short-lived trace gases and aerosol particles, in particular, is still very uncertain. The scientific understanding and research of these processes relies on high quality and harmonized datasets. The need for long-term observation of these atmospheric variables has been unambiguously asserted in the latest IPCC Fourth Assessment Report (IPCC 2007) and in the recent revision of the Thematic Strategy on air pollution of the EU. ACTRIS Aerosols, Clouds, and Trace gases Research InfraStructure Network -project (FP7-ACTRIS-I3, No 262254) is the current European level activity towards a long-term coordinated European research infrastructure of the key climate components. EU-FP7-ACTRIS-I3 is an outstanding research infrastructure launched in 2011 and active until 2015. ACTRIS will, for the first time, provide pan-European coordinated observations of the major atmospheric variables. The ACTRIS-I3 data and data products on aerosols, trace gases and clouds will fill in the gap of European SLCF research related atmospheric processes of global climate and air quality (Fig.1).

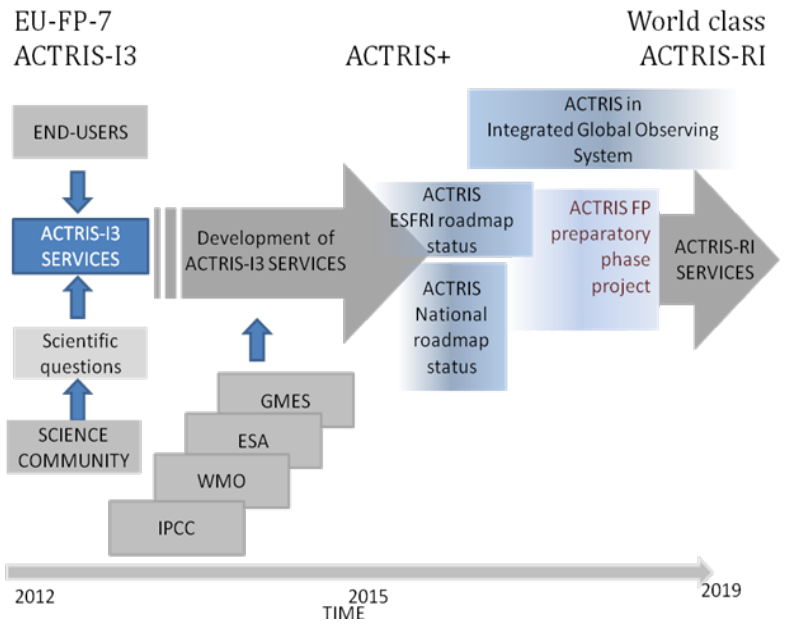

Figure 1. Vision of the process establishing a long-term, world-class ACTRIS Research Infrastructure (RI) in Europe.

1.2 Initiatives outside Europe and global actions

In order to fully exploit the future European RI data services of the key climate variables the synergy with the RI initiatives outside Europe needs to promoted. Globally harmonized observations and RIs are the most powerful tool for solving the scientific questions and finding the practical solutions for the air and climate quality policy making. Basically, the current large scale climate initiatives are lead by European Union or USA.

The USA has just recently taken an active role and has announced a new global climate initiative called "the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants" in February 2012. The aim of this initiative is to reduce the short-lived climate pollutants (black carbon, methane, hydrofluorocarbons HFCs) in the atmosphere. The founding coalition partners are Bangladesh, Canada, Ghana, Mexico, Sweden, and the United States, together with the UN Environment Programme. The coalition will be a driving force for the development of national action plans and the adoption of policy priorities, building capacity among developing countries, mobilizing public and private funds for action, raising awareness globally, fostering regional and international cooperation, and improving scientific understanding of the pollutant impacts and mitigation. It will also support the work of existing efforts such as the Global Alliance for Clean Cookstoves (a public-private partnership led by the UN to create a global market for clean and efficient household cooking solutions), the Arctic Council, the Montreal Protocol, and the Global Methane Initiative (GMI). This list of US coalition items is underlining Europe to take an action for the organization of European research infrastructures for whole palette of climate forces, not only the carbon observations (the ICOS).

For short-lived atmospheric constituents being measured within ACTRIS a gap between the political agenda and the performed long-term measurements exist in the USA. Measurements are mostly campaign driven and a lack of future-based long-term vision exists. Here Europe could lead the way to establish a harmonized measurement infrastructure as a point of reference not only for the USA, but also for Asian countries with their fast developing air pollution and climate issues in parallel with their growing economies.

In addition to the EU member state and USA originated initiatives also the international organizations have taken responsibility to foster political actions, research and infrastructure development incl. coherent monitoring of climate-active variables. Here the key organizations are World Meteorological Organization (WMO), European Space Agency (ESA) and Global Monitoring for Environment and Security (GMES), being also the potential end-users of novel aerosol and trace gases data products. For example, programmes like CLRTAP- EMEP and WMO-GAW have an international and long-term commitment through intergovernmental agreements, and serve to sustain basic operations of sites and instrumentation at decadal timescales. An organized infrastructure would build on, and directly support the needs outlined in the monitoring strategies of these organizations.

ACTIS RI will be also linked to the main international coalition of Earth observations, the GEOSS, Global Earth Observation System of Systems. ACTIS RI data products are related to nearly all societal benefit areas of GEOSS: disasters, health, climate, water, weather, ecosystems, agriculture and biodiversity.

2. ACTRIS RI Framework

The ACTRIS RI vision consists of standardized ACTRIS observations allowing world class research activities to address climate change and air quality and long-range transport of pollutants. The ACTRIS data services will support the international policies to abate atmospheric pollution and climate change. Furthermore, global exchange of aerosols, clouds and trace gases data products foster the cooperation with the networks representing other disciplines (ICOS) and other continents; Northern America and Asia.

The ACTRIS vision is built, at the first phase, on the EU-FP7-ACTRIS-I3 project. ACTRIS-I3-project is currently building the next generation of ground based components of the EU observing system by integrating the existing infrastructures: of EARLINET (European Aerosol Research Lidar Network, EU-FP5 and FP6 projects), EUSAAR (European Supersites for Atmospheric Aerosol Research, EU-FP6-project), CLOUDNET (started as a EU-FP5-project for observing cloud profiles), and a trace gas network component into a single coordinated framework. The project will prove harmonized measurements of European ground-based stations equipped with advanced atmospheric probing instrumentation for aerosols, clouds and short-lived gas-phase species and provide high quality information and services to user communities**.**

A near future goal of the ACTRIS RI Framework, in the 4 year, is to have the ACTRIS-I3 listed as ESFRI recognized project, thus (i) be part of the long-term world class pan-European RIs and (ii) be able to brought effects future research and infrastructure initiatives related to aerosols, clouds, and short-lived gas-phase species more close to the minister level decision making.

2.1 ACTRIS-I3 infrastructure

The ACTRIS-I3-project will establish a new infrastructure framework for the continuous, comprehensive advanced aerosol, trace gas and cloud measurements. By the mid of 2015 it will facilitate the data access across complementary aerosol, gas and cloud data and to combined, value-added, in-situ and profiling observations. The ACTRIS infrastructure consists of standardized ACTRIS stations around Europe and “Data Collection and Processing Centre" (DCPC) (Fig.2).

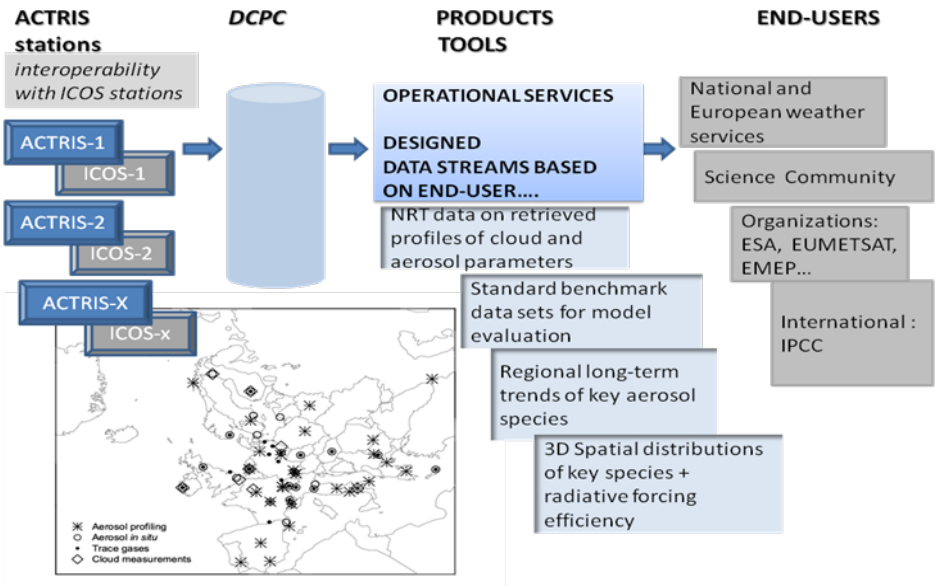

Figure 2. ACTRIS-I3 Framework as a base for long-term ACTRIS Research Infrastructure in Europe. Map of measurement sites contributing to ACTRIS-I3-project.

2.1.1 Stations network and infra

ACTRIS data during the ACTRIS-I3-project is collected from 35 active infrastructures stations around Europe for the development of the higher level data products. At the present aerosol data provided by the European stations consists on (i) vertical aerosol distribution (26 lidar stations, the EARLINET network) (ii) the in-situ aerosol properties on chemical composition, optical, cloud condensation nuclei, size distribution (23 stations, the EUSAAR network). The short-lived trace gases include measurements on VOCs (incl. NMHCs, oxidized volatile organic compounds, terpenoids) and NOxy. Albeit their importance only a very limited number of sites perform VOC measurements on a continuous basis. The term NOxy consists of nitric oxide (NO), nitrogen dioxide (NO_2) and their sum (NOx) as well as the sum of reactive oxidized nitrogen compounds (NOy). Like the VOCs measurements there is no European scale coordinated actions for the NOxy measurements and data collection.

The existing cloud observations are based on FP5 Cloudnet project (8 sites: Chilbolton (UREAD), Cabauw (TUD), Sirta (CNRS) and Lindenberg (DWD) will be extended to include new stations at Mace Head (NUIG), Potenza (CNR), Sodankylä (UHEL), Hyytiälä (UHEL), Leipzig (IFT)). New ACTRI-I3 cloud products are designed to retrieve the cloud variables such as cloud fraction, cloud liquid water and ice water content held in operational models.

All the ACTRIS-I3 stations also cover the basic meteorological observations. Part of the stations provide adequate scientific, technical and logistic support to external users (the transnational access):

- CNR-IMAA Atmospheric Observatory (CIAO), Tito Scalo, Potenza, Italy (CNR-IMAA)
- SIRTA Atmospheric Observatory (PAL), Palaiseau, France (CNRS)
- Observatory of Atmospheric Physics of Reunion Island - Maïdo Station (MAIDO), OPAR: Saint Denis de la Réunion, Réunion Island, Maïdo Station, Commune de Saint Paul, Reunion Island (Centre National de la Recherche Scientifique)
- Station for Measuring Forest Ecosystem-Atmosphere Relations - SMEAR II (SMR), Hyytiälä, Juupajoki, Finland (Univ.Helsinki)
- Cabauw Experimental Site for Atmospheric Research (CESAR), Lopik, The Netherlands (Delft University of Technology jointly with the CESAR consortium)

- High Altitude Research Station Jungfraujoch (JFJ), Jungfraujoch, Switzerland (International Foundation High Altitude Research Stations Jungfraujoch & Gornergrat HFSJG)
- Mace Head Atmospheric Research Station (MHD), Carna, Co. Galway, Ireland (National University of Ireland, Galway)
- Auchencorth Moss (AMO), United Kingdom (Natural Environment Research Council)
- Finokalia (FKL), Finokalia, Crete, Greece.(Foundation of Research and Technology Hellas (FORTH))
- Hohenpeissenberg Meteorological Observatory (HPB), Hohenpeissenberg, Germany (Deutscher Wetterdienst)
- Romanian Atmospheric research 3D Observatory (RADO), Magurele, Ilfov, Romania (National Institute of Research&Development for Optoelectronics)

As a summary, the ongoing FP7-ACTRIS-I3 is a step forward merging already existing of critical climate factors and delivering the near real time data products. After 2015 the ACTRIS stations network will consist of prototyped ACTRIS core stations. The prototyped ACTRIS station consists of a suite of tested sensors for the defined variables. The ACTRIS core station is in the first phase limited to aerosol and reactive trace gases measurements.

ACTRIS “Data Collection and Processing Centre" (DCPC) is established for atmospheric aerosol and cloud parameters as well as reactive trace gas species. ACTRIS-data will be disseminated via i) ACTRIS-I3-website and ii) data streams. Optimal format and procedures for NRT data for each variable will be defined including the initial and second level quality assurance (QA) for the incoming NRT data. The sustained ACTRIS data streams for NRT reporting include station diagnosis and interoperability between local data center and DCPC as well as data stream integration in other networks data centers.

Automatic operation and remote control procedures will be defined and standard data streams implemented. The ACTRIS core station requires interoperability with the ICOS Atmospheric stations which is to be achieved through joint development with ICOS teams. The construction of the ACTRIS prototype core station will be done in collaboration between several partners of ACTRIS and has been granted already support from national agencies (ADEME) for instrumentation investments needed.

2.1.2 Construction of higher level data products

The ACTRIS-synergetic algorithms provide advanced higher-level products which will lead to a new insights into atmospheric processes. These data products enhance scientific exchange with user communities working on models, satellite retrievals, and forecast systems. In addition to the NRT (near-real-time) data streams to GMES and WMP the major users of the advanced ACTRIS data are in the atmospheric science community in general. General model evaluation studies, satellite retrieval development, and scientific assessments for climate and air pollution policy advice make use of integrated information and coarsely gridded data products, eventually on much lower time resolution than actually measured in ACTRIS. Measurements taken in ACTRIS thus require further integration and preparation as higher level products to make the network efficient. Error documentation and sampling statistics need to be explained and documented in a form usable for model evaluation and assessments. Higher level products require on the other hand scientific judgement and need to be designed with expertise coming from the data providers. The higher-level products will be integrated with the overall ACTRIS data dissemination in collaboration with the data centre. The higher-level ACTRIS data-products are:

- Long-term trends of aerosol properties and their connection with clouds and trace gases
- Climatology of vertical distribution of key parameters over Europe
- Radiative forcing benchmark dataset
- Satellite & surface data integration tool

- Combination of meteorological information with aerosol, cloud and trace gas measurements

2.1.3 Operational services

Operational weather forecast models

The factors leading to the build-up and dispersion of pollution in the boundary layer are complex and as a result accurate forecasting of such events is challenging. The build up results from emissions into a stable, trapped, boundary layer; dilution occurs through vertical and horizontal mixing, but removal occurs mainly via precipitation - initially cloud droplets form by condensation on the aerosol particles, which may then coalesce and fall out as rain, or freeze and be removed via snowfall. Current operational weather forecast models have a horizontal resolution of 1km or so and cannot resolve these microphysical processes, instead the processes have to be parameterized in terms of bulk variables held in the model at the km scale. The precise formulation of these parameterization schemes is the cause of much of the uncertainty in the forecasts, and is an area of active research. Improvement can only take place if we have a number of well provided atmospheric observatories equipped with Doppler cloud radars and advanced lidars which provide continuous vertical profiles of the atmosphere, the motions of the air, the aerosols, the cloud particles and their phase (liquid or ice). If such stations span the climates of Europe, then they can provide data, firstly, for evaluating the performance of current weather forecasting models, and then, secondly, suggest improved parameterization schemes to improve forecast performance.

Air Quality services

ACTRIS will harmonize the on-line, trace level gaseous air pollutant measurements, yield reliable concentration fields and trends in Europe and help to quantify the relative contribution of anthropogenic sources and improve air pollution abatement strategies. This action is supporting the reliable monitoring of particulate and gaseous air pollutants at high time resolution in a standardized way across Europe and is of interest for the climate and air quality modeling community and political entities and the general public.

2.2 ACTRIS+ RI Framework

The ACTRIS+ RI framework is built on the ACTRIS-I3 RI, which is further scoped by the identification of end-users and determination services requirements for different impact areas (Fig.3). For example, ACTRIS RI has potential to develop several types of data products for several operational services, not only weather forecasts and air quality monotoring, such as traffic, hazards like forest fires, Saharan dust, volcanic etc. ACTRIS RI has an unique capability to monitor transport events complementary to satellite observations and dispersion models.

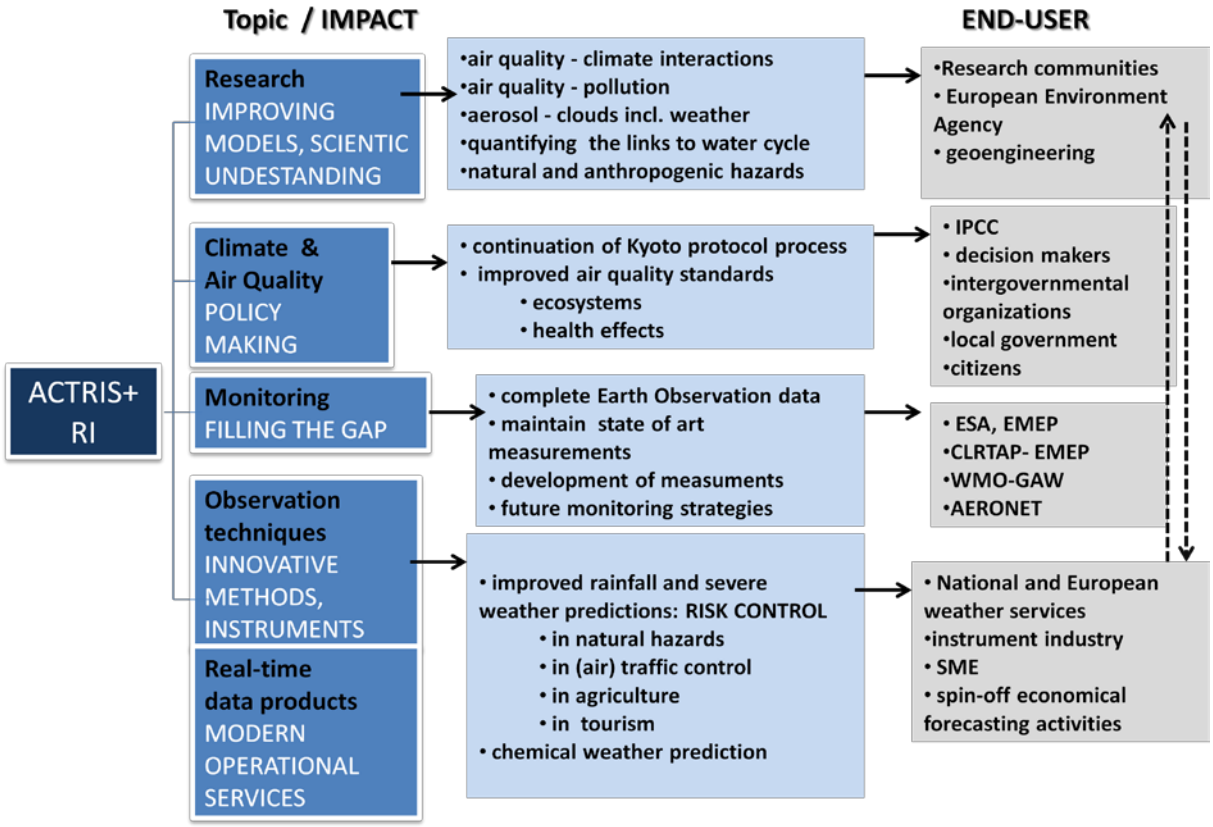

Figure 3. Big-picture on ACTRIS+ RI impact areas & end users.

2.2.1 Answers to most urgent science questions

The emerging findings of atmospheric interactions of aerosols and trace gases and their connection to biosphere and anthropogenic activities needs to be implemented into large-scale climate models, regional models and atmospheric chemistry models. Many of the existing observation networks do not deliver information with an accuracy of the vertical dependence of the atmospheric phenomena that is sufficient for reliable weather and climate modelling. European research institutes are also involved with several model inter comparisons and satellite evaluation assessments projects HTAP (Task Force on Hemispheric Transport of Air Pollution (TF HTAP) by UNECE Convention on Long-range Transboundary Air Pollution (LRTAP Convention), AeroCom, Globaer, GEWEX, ICAP (International Cooperative for Aerosol Prediction)).

Greenhouse gases like CO_2 are well-mixed worldwide, in strong contrast to aerosols that are highly spatially inhomogeneous depending on the development level of different regions. Consequently, the aerosol and clouds may have a different impact on different regional climates. The indirect aerosol effects need to be accounted for in regional climate models that can be used to develop scenarios for regional effects of climate change. Furthermore, the mixing ratios of volatile organic compounds (VOCs) and nitrogen oxides (NOxy) in the atmosphere are very variable. Athough concentrations are small, these trace gases contribute to the oxidation capacity of the atmosphere and influence the climate, as they are precursors of secondary aerosols and tropospheric ozone The models producing most reliable future climate air and air quality predictions are crucial for the European society restricting and evading the global change. Data products are needed to improve the process understanding in the models and scientific understating on the relations between (Fig.4):

- air quality - climate interactions (climate, radiative balance)
- air quality – pollution
- aerosol-cloud-precipitation
- aerosol - clouds incl. weather (cloudiness, rainfall)
- quantifying the links to water cycle and natural and anthropogenic hazards

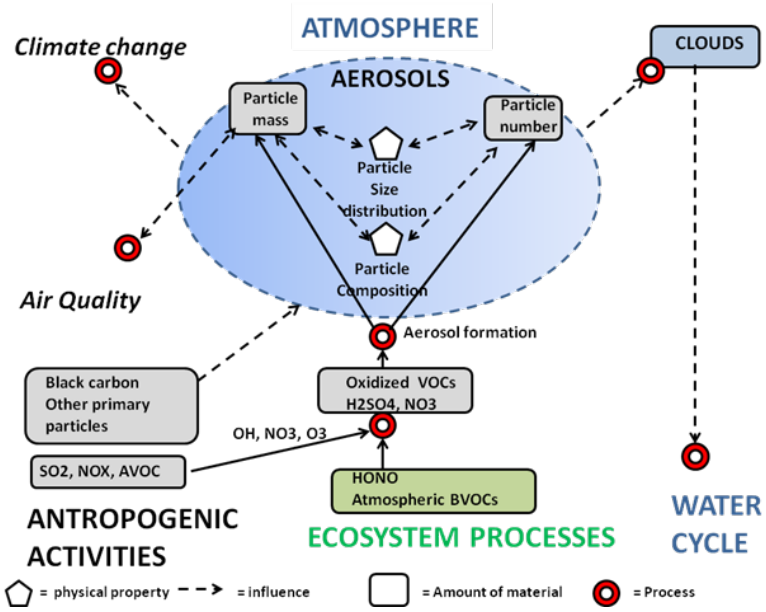

Figure 4. Atmospheric processes and links to anthropogenic activities, ecosystem processes and water cycle relevant to ACTRIS RI.

Networks with well equipped aerosol observations combined with aircraft observations and satellite observations provide new data that can be used in evaluating the performance of large-scale atmospheric models and in model applications requiring data assimilation. It is underlined that several processes (boundary layer mixing, particle formation, convection, wet removal, effective emission height, aerosol ageing and aerosol-cloud interactions) influence the vertical distribution of the aerosol processes described in the climate models and are almost impossible to be studied at a single measurement site.

Furthermore, state-of-the-art measurement techniques of trace gases and aerosols is rapidly expanding. During the last years the in situ analysis of particulate organic compounds at individual sites has been expanded to coordinated measurement programs at networks of stations. Also, the modern mass spectrometric techniques have revolutionized aerosol chemical observations by allowing the determination of all major organic and ionic inorganic chemical constituents of submicron particles virtually in real time. The new techniques have increased sensitivity of aerosol chemical measurements. For the first time aerosol composition data is provided at time scales comparable to meteorology, aerosol dynamics and gas-phase chemistry and a new understanding on carbon-containing compounds to be implemented to regional chemical transport models is in vision.

Clouds are one of the major sources of uncertainty in future climate predictions. The crucial question is, how future clouds will respond to global warming. Low-level water clouds cool and high-level ice clouds tend to warm the atmosphere, the net effect being the cooling of the Earth's atmosphere by about 10 degrees Celsius. Climate models cannot properly deal with clouds, since the spatial resolution of these models is coarser than the scale of most cloud processes. Significant correlations between many cloud variables, cloud regime and aerosol abundance have been observed. While the ultimate testing of the cause of such correlations probably relies on models, it is important to well prepare and classify the aerosol and cloud observations for different pollution levels and cloud regimes, so that they can be used in models. Also measurement error and ambiguity associated with cirrus, thin clouds, dust, sensor detection limit and cloud-aerosol discrimination algorithms require thorough investigations.

As a summary, the ACTRIS measured climate components are needed to form the holistic science understanding, how the intensity of anthropogenic actions, ecosystem biological activity and the water cycle are inter-liked with climate system. Trace gases and atmospheric aerosols are tightly connected with each other via physical, chemical, meteorological and biological processes occurring in the atmosphere and at the atmosphere-biosphere – water cycle interfaces. For example the precipitation

response and thus the hydrological sensitivity differ strongly for greenhouse gas (GHG) forcing and aerosol (AE) forcings. Decreasing aerosol emissions in the future can lead to an even stronger increase in precipitation as can be expected from GHG forcing alone.

2.2.2 Climate and Air Quality Policy

Climate Policy

The most important global effort committing countries to reducing global warming has been the Rio Convention (1992) and Kyoto Protocol (2005). The countries signing the Kyoto protocol have committed to reduce their overall emissions of six greenhouse gases by an average of 5.2% below 1990 levels between 2008-2012. The international debate on the future of Kyoto protocol is currently going on. The latest United Nations Climate Change Conference was held in Durban, South Africa, end of year 2011. The guidelines for the emission reduction policy and the future content of the process is set by Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC). IPCC has set the goal of 25-40% reduction of green houses gases by the year 2020. European Union will determine it's reduction goals during 2012. In the global climate the context IPCC forum is one of the most import end-user and collaborators of ACTRIS RI. ACTRIS RI responds to the need of long term high quality data in particular for aerosols addressed by IPCC. ACTRIS data sets are needed:

- for testing the skill of the various climate models in their treatment of clouds
- for identifying as a major source of uncertainty in predictions of global warming needed for the IPCC assessment reports and the US initiatives.
- for identifying the natural and anthropogenic contribution

Air Quality Policy

Health effects due to air pollution and the potential damage from climate change are one the most important environmental problems facing European Union. The quantification of the contributions of different anthropogenic and natural sources to the aerosol particle concentrations and new information on particle hygrosopicity and composition, along with the source apportionment, needs still to be improved. Furthermore, the continuation and up-to-date information of the EU-FP6-EUCAARI-IntegratedProject databank needs to be ensured (the knowledge on regional aerosol loadings, estimates on hygroscopicity (related to dose of the population from the loadings) and composition (related on toxicity of the particles) and estimates on how much of the loading is long range transport).

ACTRIS + social benefits are optimum if timely, high quality, and long-term data and models are available to aid air quality decision-makers at every level, from intergovernmental organizations to local government and then to citizens. Long-term information on trends are crucial to understand aerosol cycling and effectiveness of air quality policies.

2.2.3 Filling the gap in existing and future monitoring

Existing monitoring

A long-term ACTRIS type of European scale infrastructure is needed to maintaining and developing the state of the art of observations for short-lived compounds and cloud properties. The ACTRIS infrastructure builds on, and directly supports the needs outlined in the monitoring strategies of CLRTAP-EMEP & and WMO-GAW. These programmes, having an international and long-term commitment through intergovernmental agreements, serve to sustain basic operations of sites and instrumentation at decadal timescales. Furthermore, near-real-time and higher-level products and prototypes of ACTRIS are needed by international bodies such as MACC, WMO, EMEP, EU DG's, IPCC.

UN Convention on Long-range Transboundary Air Pollution (CLRTAP) and the EMEP program is a well established end user of the ACTRIS research infrastructure. The basic EMEP monitoring is founded in obligations to the international conventions CLRTAP/EMEP and WMO-GAW and relies on national funding. In EU-projects like EUSAAR, EARLINET, CLOUDNET, ACTRIS support is given to improve methodologies and support access to sites and distribution of data to broad user communities. This is an important link between the scientific communities and the stake holder EMEP, and contributes to further development of the EMEP program. To ensure involvement of the scientific community in the policy making, EMEP has established a Task Force on Measurements and Modelling. The task force is co-chaired by the WMO-GAW, and meets annually to discuss scientific issues associated with the operational observations. The ACTRIS-I3 will through participation at the Task Force meetings ensure strong linkages with the EMEP efforts. This can be illustrated by the fact that ACTRIS is directly referred to in the official workplan of EMEP for 2012-2013[1].

Earth Observation

The sustained long-term observations of a comprehensive suite of atmospheric parameters needs be accomplished be three approaches: (i) multiple coordinated in-situ stations completed by (ii) ground-based remote sensing observations and (iii) EO data. Satellite observations are only capable to a limited degree to fulfil this task as it is difficult to collocate the required complex sets of instruments on space platforms. Moreover, satellite observations do not have a sufficient temporal and even spatial coverage and continuity to study many processes and do need ground-based measurements for calibration and validation (GCOS, 2006). ACTRIS portal will also offer a direct interface towards external users like the MACC project (Monitoring Atmospheric Composition and Climate - Interim Implementation - pre-operational atmospheric service of the European GMES programme) GMES and ESA. Furthermore, ACTRIS represents a promising example towards a global environmental information system whose outcomes and benefits, according to GEOSS (The Global Earth Observation System of Systems) will include:

- weather and air quality monitoring, forecasting and advisories
- public understanding of environmental factors affecting human health and well being
- natural hazards and disaster reduction
- integrated water resource management
- sustainable land use and management
- better development of energy resources
- influence on the decision-makers

However, there are still existing gaps of information, which could be filled by taking advantage of the long-term measurements**.** Until recently, investigating aerosol optical properties at continental and global scales was based mainly on columnar measurements with passive remote sensors aboard satellites and/or ground-based sun-photometer networks like AERONET (AErosol RObotic NETwork). These instruments cannot provide information about the vertical layering of aerosols, which would be crucial for aerosol source identification, aerosol-cloud interactions, air quality impacts, and aerosol influences on the radiation budget. The existing gap of information could be filled by taking advantage of the long-term measurements of vertical profiles of aerosol properties currently available from ground-based lidar networks and satellite-borne lidar measurements.

In general, ACTRIS vision is to further develop these elements to even further address future needs for information for atmospheric research, and in a way which complements other related research infrastructures initiatives. The development of the measurement activities rest on research institutions, which need novel and new instrumentation for studying the atmospheric processes.

2.2.4 New observation techniques and innovations

[1] http://www.unece.org/fileadmin/DAM/env/documents/2011/eb/ge1/ECE.EB.AIR.GE.1.2011.10.e.pdf

New observation technologies developed in ACTRIS can be implemented at locations in different climate regions and will enable local governments to base their policy on a more accurate expectation of regional climate change, as well as the industry to develop appropriate products and technologies to counteract or adapt to climate change. This is an important development, especially in light of a future climate change and the consequences thereof, since climate monitoring will increasingly become vital for future societies. Many spin-off economical activities, based on improved rainfall and severe weather predictions, are to be expected; e.g. in natural hazards, in (air) traffic control, in agriculture and tourism. The development of new methods and instrumentation has also significant impact on European SMEs, innovation, market etc.

The new emerging area in global change is geo engineering or the clime change engineering. The term climate engineering covers a number of different technologies which aim to achieve large-scale technical intervention in the climate system, but which, at the same time, differ substantially with regard to the associated risks, effectiveness, side-effects and cost of deployment. The climate change engineering is designed to effect the Earth's radiation budget in two ways: altering the Earth's radiation budget without reducing greenhouse gas concentrations, (ii) reducing the greenhouse gas concentrations that have changed the Earth's radiation budget. Both approaches requires detailed scientific understanding on cloud formation processes, which is the key component of ACTRIS RI research questions.

2.2.5 Real-time data for the operational services

It has become apparent that there will be large regional differences in warming due to human activities, as concluded in the IPCC 4AR (2007). Some of these differences are due to the changing surface conditions such as occur when snow has melted over land or sea ice has disappeared. Others are due to permanent changes in circulation or precipitation patterns. It is clear however, that the regional monitoring of climate change is important to document to what extent the predicted climate change will actually occur and to take it into account in the weather forecast and climate models. Most climatic regions of Europe should be represented by at least one core station for high resolution observations from the Northern Europe to the Mediterranean, from the Atlantic Ocean on the West to the Eastern Mediterranean.

National and European weather services need ACTRIS measured climatic components for testing improved parameterizations in weather forecast models and their ability to better predict hazardous weather. National Weather Services need to evaluate to evaluate cloud aerosol and other air pollutant (such as O_3) schemes in forecast models. Special relevance is the critical inquiry on the need of near-real-time dissemination of data for chemical weather prediction, to policy makers at all levels, and to the general public (e.g. "Shared Environmental Information System" SAIS, WMO "Weather Information System" WIS). The EUMETNET Composite Observing System (EUCOS) Operational Programme provides a community for ACTRIS+ to link its products to European weather services. The EUCOS operates a European observing network under EUMETNET (European Meteorological Services Network) and supports to development of better-quality numerical and general forecasts on a European scale.

ACTRIS data is needed for service development related to natural and anthropogenic hazards and Earth observation data integration (satellite, airborne and in-situ) (see Earth Observation in chapter 3.2.3). Natural and anthropogenic hazards cover the risks in the different types of geoscience areas, including: climate, air pollution, water management, sedimentology, geohazards, flooding risks.

3. Action plan towards long-term, world class ACTRIS RI

3.1 General timeframe

The ACTRIS project is establishing an action plan to ensure that the overall vision can be sustained beyond the project time scale. During the I3 project ACTRIS consortium will form tight links to science community and the end-user listed in chapter 3.2 and scopes it's future services for the long-term operational services. The I3-project sets up the harmonized observations networks, European level RI

efforts and management (data centre and coordination node) and provision of data products and services by the year 2015.

Establishment of the long-term ACTRIS RI will take action at i) national, ii) European, and iii) international levels. The national level covers the national ACTRIS roadmap status, establishing national ACTRIS-RIs to coordinate the national level ACTRIS activities. National RI status is needed for earmarking of national budgets for to participating in a common pan-European effort. At the European level, the strategic goal is to determine the ACTRI RI position in the ESFRI framework and determine both the current key gaps of knowledge and the services compared to other the climate related RIs (ICOS-The integrated carbon observation system, SIOS - The central node in the global monitoring of the High Arctic, IAGOS – In service Aircraft for Global Observing System). In the global level ACTRIS will start the dialogue with potential end-user groups, which will set the baselines for determining the future ACTRIS services. Several European and international organizations such as GMES, ESA, UN conventions, GEOSS and protocols (e.g. CLTAP-EMEP), WMO – GAW, IPCC (see Fig.3) could be seen as potential end-users of ACTRIS data for their air quality and atmospheric services and civil protection. ACTRIS would also build the European atmospheric component of the WMO Integrated Global Observing System (meteorological and other environmental observations; surface-based and space-based subsystems).

The estimated timeframe of the process from the ACTRIS-I3 project to ACTRIS world-class European RI in operation would be 8 years (Fig.5). 1) EU-FP-7-ACTRIS-I3 years 2011-2015, 2) National ACTRIS Roadmap Statuses established by 2015, 3) ACTRIS-ESFRI-Roadmap-proposal submission and status in the next ESFRI Roadmap update process (approx. **2014/15)**, followed 4) ACTRIS-RI pan-European Infrastructure Preparatory Phase, 4 years with last two years for RI construction, and 5) Start of operation in 2019.

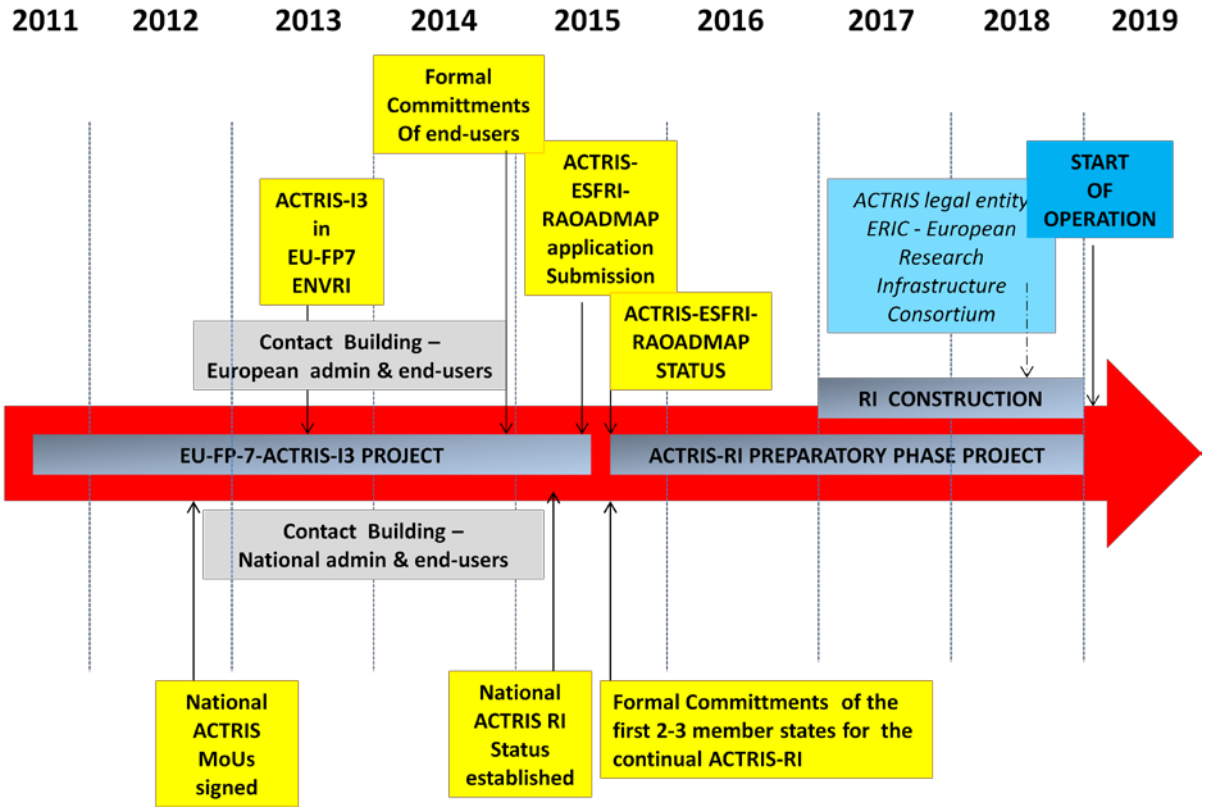

Figure 5. The estimated schedule of the process from the ACTRIS-I3 project towards ACTRIS world-class European RI in operation.

3.1.1 National ACTRIS-RI status

In the national level the ACTRIS-I3 partners will make ACTRIS visible in their countries. Each ACTRIS-I3 partner institute will determine their national ACTRIS-roadmap and establish a national ACTRIS community as a collaboration forum of researchers and/or institutes in a frame of ACTRIS. In the national roadmap the strategic research agenda and plan in national level will be explained. The key scientific questions and aspects related to ACTRIS RI will be addressed. The research topics will cover interactions between on air quality- climate change and the description of measurements (in situ, ground based, ground based remote sensing) on aerosols, cloud properties and short-lived gases and the description, how ACTRIS RI will benefit the national research community answering these questions.

In order to consolidate the European ACTRIS-I3 project and the future European ACTRIS+ RI ACTRIS partners will build contacts with the national research administration and organizations such as National Met.Services, space agencies and national research activities. Formal agreements with National Met.Services, Research Institutes and programmes are needed to secure commitment by stakeholders, as well as through an efficient organization of the institutions. The long-term commitment at the national level is attained via the national RI-status, which is the final aim of national ACTRIS-RIs.

Most of the observation sites and institutions involved in ACTRIS serve also as contributors to other research infrastructure initiatives. In order to mobilize as wide community as possible also the ESFRI related national project like ICOS are contacted. The establishment of national ACTRIS community is scheduled for 2012-2013. The first national ACTRIS community including a national research group and a steering group has been established in Finland, the kick-off meeting in October 2011 (http://www.atm.helsinki.fi/multisites/actris/).

3.1.2 ACTRIS-I3 towards ESFRI roadmap status

The ACTRIS-I3 partners will analyze current the European RI landscape and establish a joint coordination body for this task. The specific actions towards the ESFRI Roadmap status are:

(i) start the dialogue with already existing ESFRI projects like ICOS, COPAL, SIOS, IAGOS, EPOS and LifeWatch and seek its position in the ESFRI framework. Including analysis of the knowledge gaps vs. ongoing ESFRI initiatives and networks. For example ACTRIS-I3- data centres of short-lived climate forcers not covered in other ESFRI initiatives. Also the best practices and lessons learnt from ESFRI projects will be analyzed.

(ii) In order to integrate more tightly to the ongoing re-organization of the European research infrastructure ACTRIS-I3 will joint EU-FP-7 e-infra project ENVRI "Common Operations of Environmental Research Infrastructures". The ENVRI project is a collaboration effort of the ESFRI Environment Cluster, with support from ICT experts, to develop common e-science components and services for their facilities. The results will speed up the construction of these infrastructures and will allow scientists to use the data and software from each facility to enable multi-disciplinary science. The target is on developing common capabilities including software and services of the environmental and e-infrastructure communities.

(iii) ACTRIS will start establishing international links to related RI networks in other continents. ACTRIS will also benefit from trans-Atlantic collaboration of ESFRI environmental cluster. For example, ACTRIS is one of the key I3-projects listed in COOPEUS – Building a Framework for a Sustainable, Transatlantic Cooperation in the Field of Environmental Research Infrastructures. (*INFRA-2012-3.1 International cooperation with the USA on common data policies and standards relevant to global research infrastructures in the environment field*). The COOPEUS project interlinking activities of the Europe's major environmental research infrastructure projects within ESFRI (i.e. EISCAT, EPOS, LifeWATCH, EMSO, ICOS) with their US counterparts (AMISR, EARTHSCOPE, DataONE, OOI and NEON). The thematic link from

ACTRIS together with ICOS to COOPEUS is radar, lidar data: integration of ground based stations, tools and standards.

(iv) Joint Programming Initiative – JPI Climate, which aims for strategic research funding and research collaboration on climate research at the European level, will benefit greatly from ACTRIS RI efforts because ACTRIS provides essential data and services for the JPI Climate research community. In addition JPI Climate also the links between ACTRIS and JPI FACCE (Agriculture, Food Security and Climate Change), JPI URBAN EUROPE and JPI Oceans (Healthy and Productive Seas and Oceans) are analyzed

Actions (i) and (ii) are followed by preparing the ACTRIS-I3 for the ESFRI review process and the preparation of ACTRIS-ESFRI Roadmap application. Based on "Procedure on preparing the 2nd update of the ESFRI Roadmap the ACTRIS-I3 needs to:

- identify the present and future needs of the scientific communities and political stakeholders
- demonstrate impacts on scientific developments, support new ways of doing science in Europe and contribute to the growth of the European Research Area
- demonstrate the degree of maturity
    - o existence of a technical concept, feasibility studies including identification of technical challenges and risks
    - o existence of a defined estimate about construction, operating and decommissioning costs, including a clear timetable.
    - o information on an updated peer review of the project, the potential for risks- and costs sharing and for developing effective joint actions in Europe, the mechanisms for other partners to join later on and the mechanisms to ensure the human resources.

The next open call for the ESFRI roadmap status applications in the area of Environment RIs is preliminary scheduled for 2014/2015 .

3.1.3 ACTRIS RI integration to existing pan –European and international activities

In order to boost the integration of ACTRIS RI into international observation activities and strengthen it's position in the European research infrastructure landscape the ACTRIS-I3 will start the dialogue with the potential end-user communities listed in Chapter 2.2. In order to consolidate the strategic aims formal and written agreements and Letters of Commitments are aimed to be signed with all partners, national level shareholder committees and with organization (ESA, GMES etc.) representing large-scale coordination actions and potential end-users of ACTRIS-RI services.

List of acronyms

ACTRIS-I3	"Aerosols, Clouds, and Trace gases Research InfraStructure Network" project, European Commission FP-7-Project
CLOUDNET	EU-FP5-project, cloud profiling.
CLTAP-EMEP	Convention of Long Range Transboundary Air Pollution (CLTAP) - European Monitoring and Evaluation Programme
DCPC	Data Collection and Processing Centre
GAW	The Global Atmosphere Watch programme WMO provides reliable scientific data and information on the chemical composition of the atmosphere, its natural and anthropogenic change, and helps to improve the understanding of interactions between the atmosphere, the oceans and the biosphere
GHG	greenhouse gas
EARLINET	European Aerosol Research Lidar Network
EPOS	Multidisciplinary seafloor observatory
ESA	European Space Agency

ESFRI	European Strategy Forum on Research Infrastructures
ERIC	European Research Infrastructure Consortium
EUCAARI	European Integrated project on Aerosol Cloud Climate and Air Quality Interactions, 2007-2011, EU-FP6 project
EUSAAR	European Supersites for Atmospheric Aerosol Research, EU-FP6-project
GMES	Global Monitoring for Environment and Security. the European Programme for the establishment of a European capacity for Earth Observation
NMHCs	C2-C9 hydrocarbons
OVOCs	oxidised volatile organic compounds
VOC	volatile organic compounds
IPCC	Intergovernmental Panel on Climate Change
SLCP	Short-Lived Climate Pollutants
UN	United Nations
WMO	World Meteorological Organization

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