

MC-FORUM: the ASI-funded project for the meteorological and climatological exploitation of FORUM

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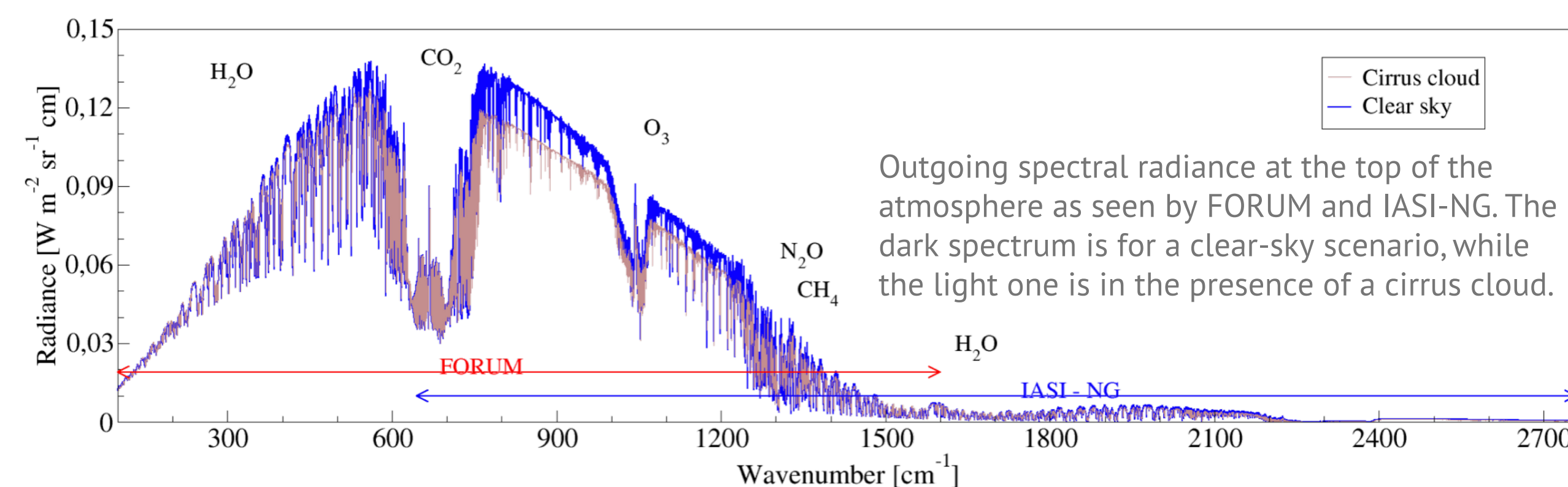
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Rationale

Satellite observations play a major role in operational meteorology, providing homogeneous and global data on the Earth's atmosphere and surface, exploited through Data Assimilation (DA) to produce estimates of the Earth system state. The FORUM (Far-infrared-Outgoing-Radiation Understanding and Monitoring) mission is the ESA 9th Earth Explorer (EE9), scheduled for launch in 2027, which will collect spectrally resolved radiance fields in the Far InfraRed (FIR) and Mid InfraRed part of the spectrum, spanning the 100 to 1600 cm^{-1} band with 0.5 cm^{-1} un-apodised resolution.

The FIR wavelengths are currently unexplored from space despite they constitute a large fraction of the planet's outgoing longwave radiation (OLR). This spectrum embeds the signatures of several climate forcings and related feedbacks, also being highly sensitive to upper tropospheric water vapor and cirrus clouds, and it is crucial for assessing the Earth's radiation balance.

MC-FORUM (Meteo and Climate exploitation of FORUM), a two-year project funded by the Italian Space Agency (ASI), will start at the end of 2023, with the primary objective of developing tools and skills to exploit FORUM in the meteorological and climate fields. It will study the impact of FORUM data on different spatio-temporal scales and different DA techniques, variational and ensemble-based Kalman filter-like. It will also develop tools to exploit FORUM measurements for diagnostics and validation of global climate models, for enabling the study of new parameterizations and the benefits of FORUM in the evaluation of radiative forcings and climatic feedbacks.



Methods

The development will start from numerical weather models and from climate models (atmosphere-only and coupled atmosphere-ocean models), with different characteristics depending on the space-time scales to be investigated. The models will be adapted and operated for the use of the FORUM measurement, integrating the σ -IASI/FORUM radiative transfer model designed to operate on the spectral range of the FORUM observations. Various data assimilation procedures will be developed, both variational methods and Monte Carlo ones based on the Kalman filter. WRF (Weather Research and Forecasting model) will be a reference code for short/medium term simulations. Impact tests of the FORUM DA will be carried out via OSSEs (Observing System Simulation Experiments).

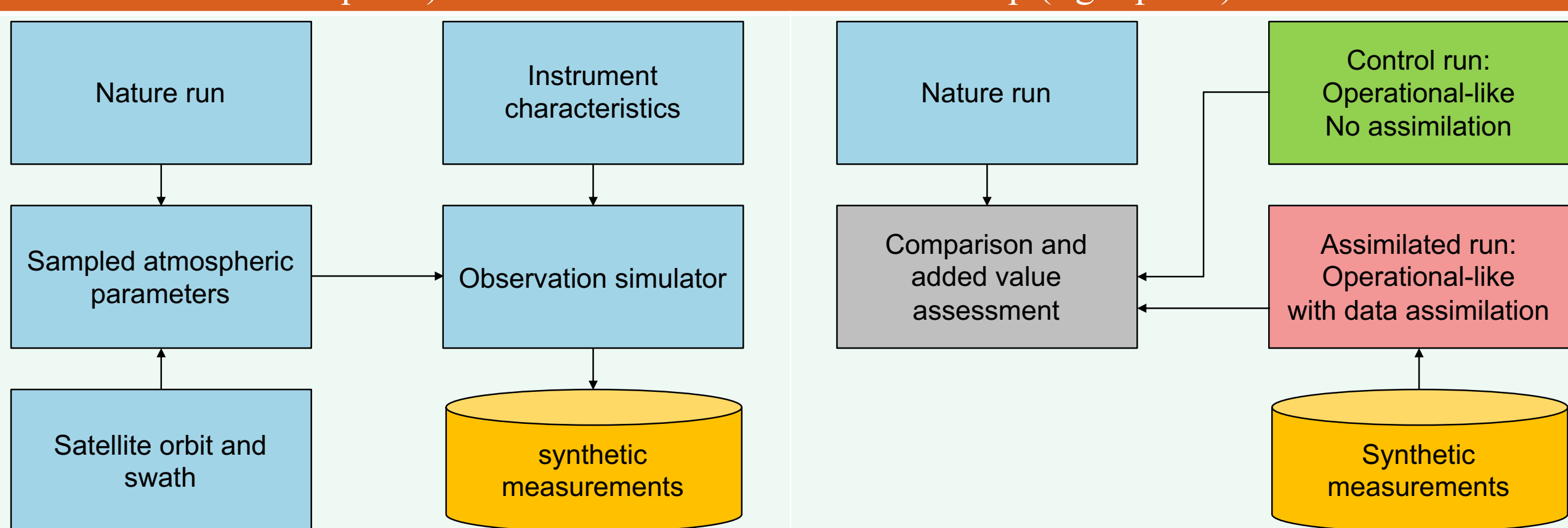
The impact of FORUM on EnKF data assimilation systems will be also addressed, to produce proof-of-concepts and benchmarks of the feasibility, quality and possible limitations of EnKF in the DA of Level 2 products. We will work with idealised models, of low and/or intermediate complexity, but which allow a deep benefit analysis, even in multi-scale or coupled systems.

The potential of FORUM measurements for the control and initialization of forecasts at seasonal and interannual scales will be investigated. About climate, it is essential that models faithfully reproduce the energy imbalance at the top of the atmosphere (TOA) to make reliable projections. The use of spectrally resolved measurements, as IASI and FORUM, will allow the separation of model biases in different spectral regions, developing tools for the diagnostics of numerical models of global climate, as well as the study and validation of new parameterizations. The potential of FORUM in the study of radiative forcing and climate feedback will be also investigated.

The reference model will be EC-Earth3, a cutting-edge climate model that participates in CMIP6 (Coupled Model Intercomparison Project – Phase 6), developed by a consortium of European research institutes, including two project partners. Part of the work will concern the development and implementation of the σ -IASI/FORUM

simulator within EC-Earth3, also under cloudy skies and the production of simulations in CMIP6 climate change scenarios. A synthetic radiance climatology will be produced in a present-day historical simulation also to generate synthetic data to evaluate the sensitivity of the measurement to: 1) the model tuning parameters; 2) the future evolution of the climate system.

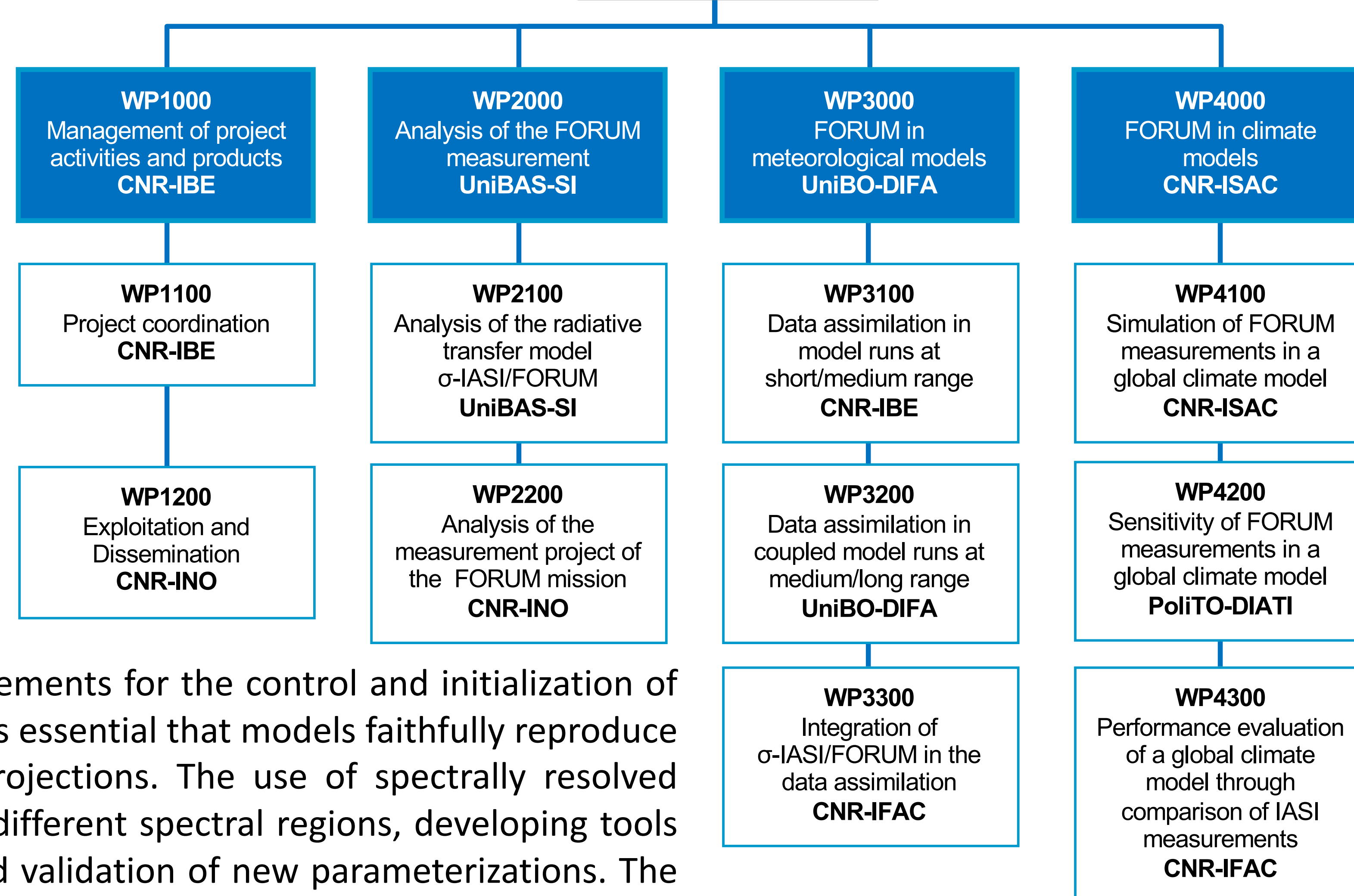
Observing System Simulation Experiment (OSSE) scheme: synthetic data generation step (left panel) and data assimilation evaluation step (right panel).



Connections with other ongoing projects

The main collaboration will be with FIT-FORUM (Forward and Inverse Tool for FORUM), a two-year project funded by ASI in the same call, focused on direct and inverse models for the simulation and retrieval of the FORUM measurements. A second close interaction is foreseen with EMM (Earth Moon Mars), a three-year research infrastructure PNRR (National Plan of Recovery and Resilience) project, which has a WP branch focused on building a research infrastructure based on SW procedures and High Performance Computing platforms for future satellite measurement simulations and product exploitations in meteorological and climatological models, with FORUM being the first future satellite mission to address.

MC-FORUM



Project structure

MC-FORUM is organised in 4 Work Package (WP) branches. The first one is for coordination, exploitation and dissemination of the project results. The second one is for collecting state-of-the-art FORUM procedures and data, somehow a bridge with the project FIT-FORUM. The third one is for meteorological studies at different space-time scales, and includes the integration of the radiative transfer model σ -IASI/FORUM. The fourth one is to evaluate the potential of FORUM measurements to tune and develop parameterisations for climate models.

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