Status and plans for ecRad radiation at Météo-France

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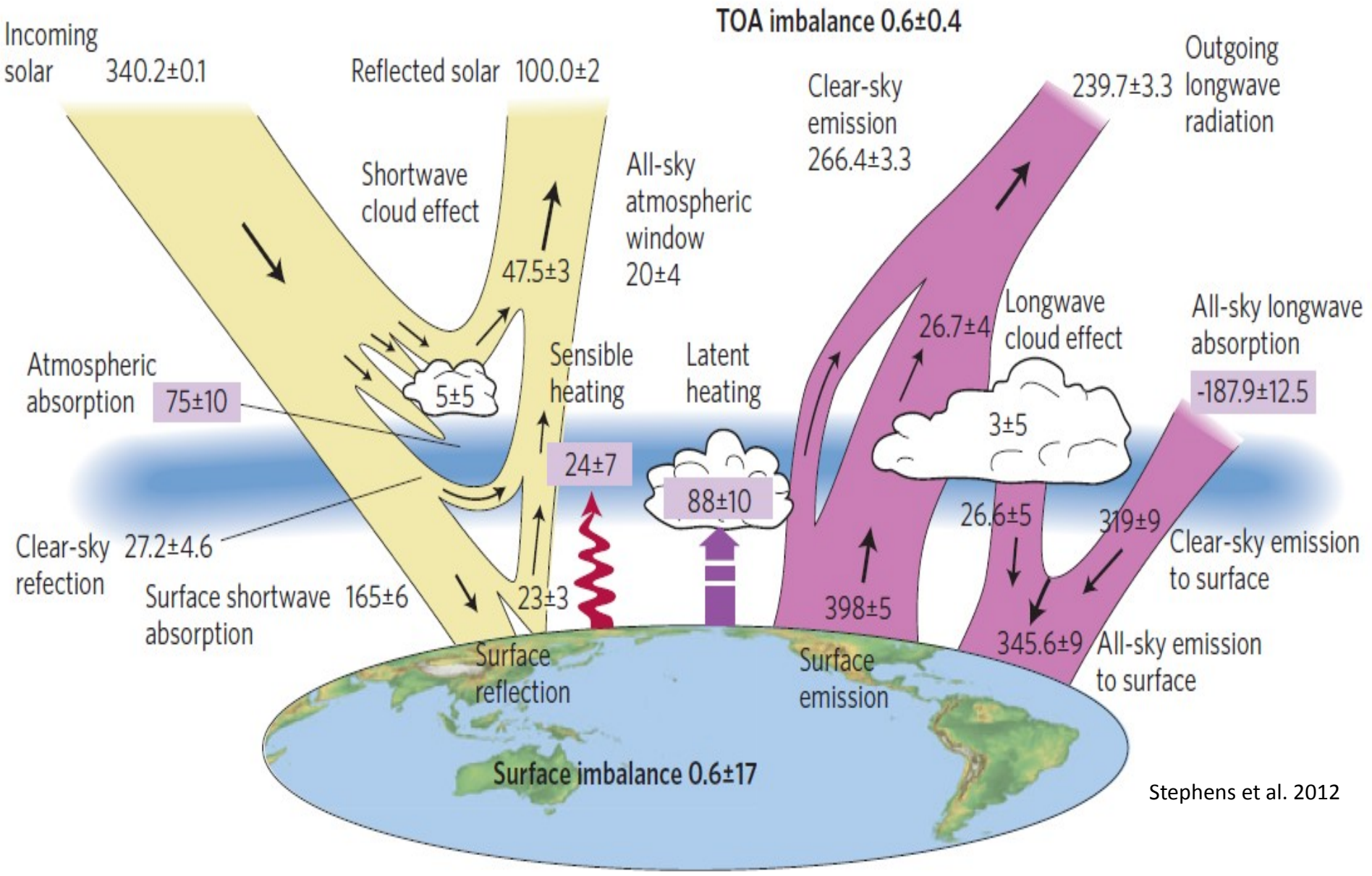
Radiation budget drives climate and weather

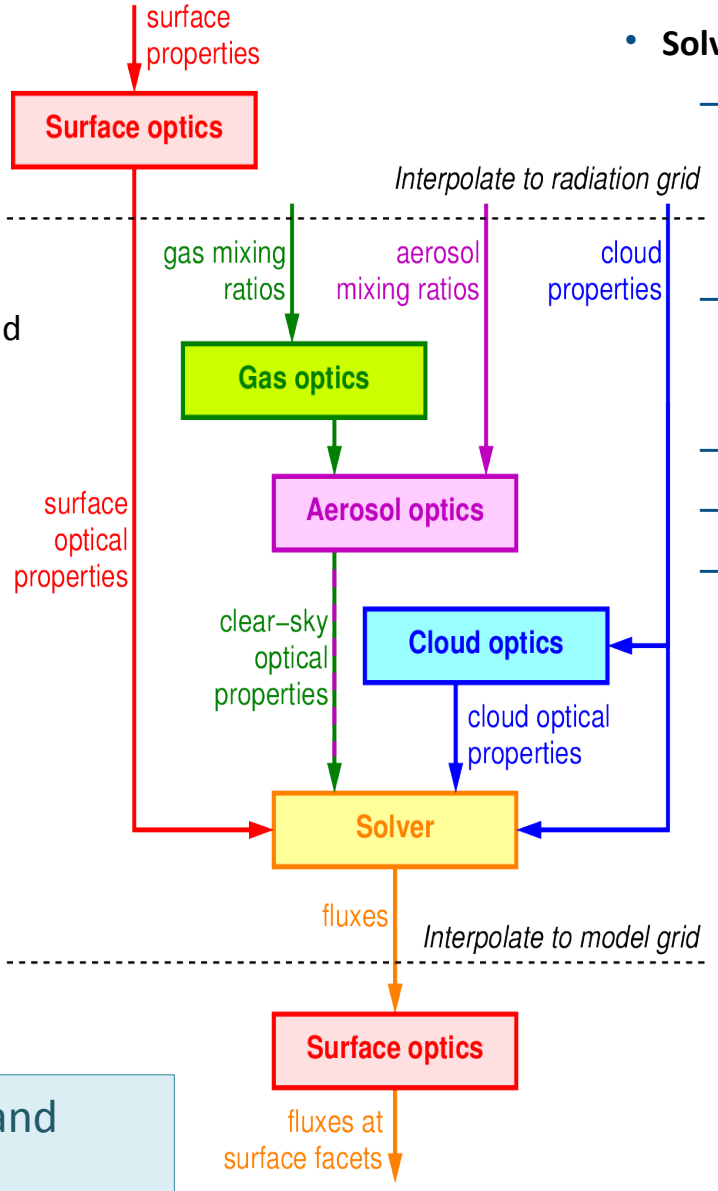


Stephens et al. 2012

Models tuned to top-of-atmosphere radiative fluxes (directly observable), ideally bias < 1W/m²

New modular radiation scheme ecRad (Hogan & Bozzo 2018)

- **Gas optics:**
  - RRTMG (Iacono et al. 2008)
  - ecCKD (Hogan & Matricardi 2020): Fewer spectral intervals but similar precision
- **Aerosol optics:** variable species number and properties (set at run-time)
- **Cloud optics:**
  - **liquid:** SOCRATES (MetOffice), Slingo (1989), Mie calculation
  - **ice:** Fu 1996, 1997, 1998 (default) , Yi et al. 2013 or Baran et al. 2014,
- *Surface: Consistent treatment of urban and forest canopies*



- **Solvers** for radiative transfer equations:
  - **McICA** (Pincus et al. 2003), **Tripleclouds** (Shonk & Hogan, 2008) or **SPARTACUS** (Schäfer et al. 2016, Hogan et al. 2016)
  - SPARTACUS makes ecRad the only global radiation scheme that can do sub-grid **3D** radiative effects
  - Longwave scattering optional
  - Can configure **cloud overlap**
  - **Cloud inhomogeneity**: can configure width and shape of PDF

Implemented in ARPEGE, AROME and Méso-NH (update in progress)

Tasks for radiation / ecRad expert

1. Take charge of 3 models (Meso-NH, AROME, ARPEGE) : code and run. Implies formations: Meso-NH (February), Vortex-Olive … Meso-NH new implementation + ecRad update in progress

2. Share same version of ecRad in 3 models – workflow next slide

3. Adjust configuration of ecRad (namelist + input), probably different for 3 models (cloud + aerosol optical properties, overlap assumption, ...). Consistency with other parameterizations (microphysics, cloud scheme …) recurring issue

4. Develop evaluation methodology for 3 models of different ecRad options (SPARTACUS, TripleClouds …) + other parametrizations (microphysics, cloud scheme ...). Magnaldo et al. (2023, AROME) : pyranometers France, also available : DWD, BSRN, etc., highly instrumented sites (SIRTA, Meteopole-Flux …), campaigns; satellites

5. Follow evolution of ecRad with other users, update to new versions - update of MesoNH to ecRad 1.6.1 ongoing

6. Contributing to ecRad development, e.g.:

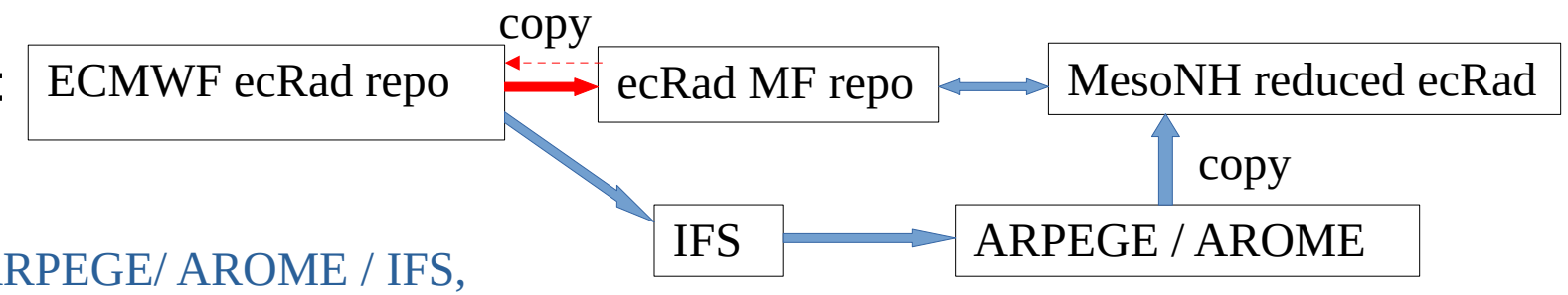
- better consistency of aerosols between radiation/microphysics and chemical/aerosol scheme (ORILAM in Meso-NH), aerosol optical properties

- 3D radiation : SPARTACUS (sub-grid) and 3D explicit approaches - see 3D status / ideas

+ Links to ECMWF, ecRad developers and users, cross-scientific coordination of radiation between different actors at CNRM and other French laboratories through the DEPHY group – meet colleagues at ECMWF, Météo-France, DMI regularly ; HIRLAM/ACCORD physics groups, DEPHY seminar

Implementation of ecRad in Meso-NH
(ideally consistent with ARPEGE/AROME and IFS)

Planned workflow:



+ : consistent with ARPEGE/ AROME / IFS, efficient, - : has to be copied manually for consistency with full offline ecRad (for now)

New implementation of ecRad and update to version 1.6.1 ongoing
Plan to include ecRad in Meso-NH as external library

Future plan (ECMWF): also include ecRad in IFS → AROME/ARPEGE as external library : easier, cleaner code (in some months)

Scientific options (Q. Libois):

- Cloud optical properties accounting for particle shape distribution, habit: liquid (with E. Jahangir), ice (with M. Taufour)
- CAMS aerosol climatology
- Spectral emissivity

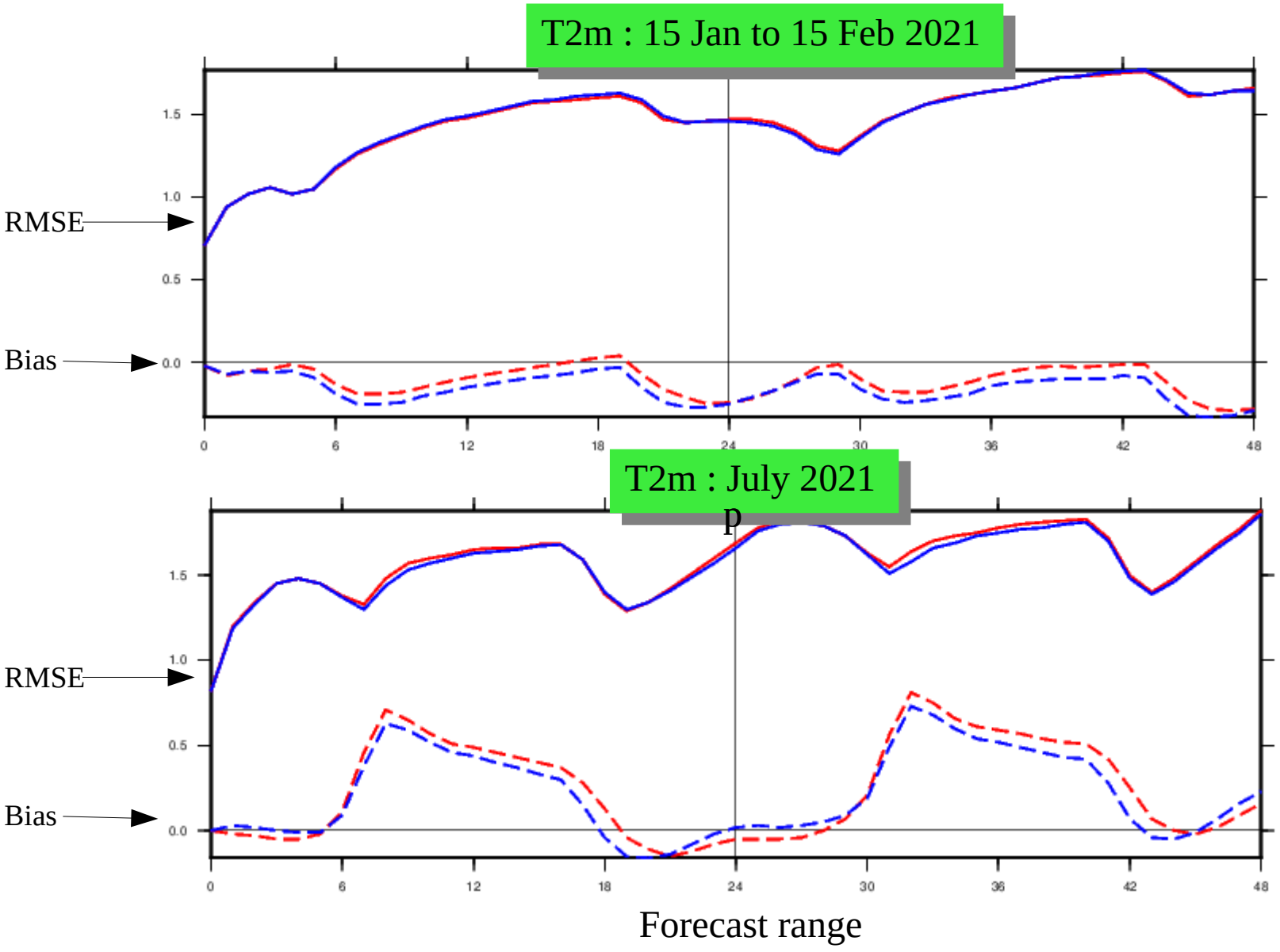
Reduced radiation grid (implemented by V. Masson)

Radiation + aerosol status in AROME/ARPEGE (Y. Seity)

	OPER(CY46T1)			E-Suite (CY48T1)			E-SUITE (CY49T1) (under development)		
	SW	LW	Aerorols	SW	LW	Aerosols	SW	LW	Aerosols
AROME	Fouquart-Morcrette	RRTM	Tegen 2D clims (6 var)	ecRad (SRTM McICA)	ecRad (RRTM McICA)	CAMS 3D clims (11 var)	ecRad (SRTM McICA)	ecRad (RRTM McICA)	CAMS 3D clims (11 var)
ARPEGE	SRTM					Tegen 2D clims (6 var)			

- Tests of near-real-time CAMS aerosol for CY49T1_op : improvements for dust outbreaks
- Future : code optimisations, further model tests
- Possibly also test ecRad versus ACRANEB2

Comparison ecRad versus Oper (Y. Seity)

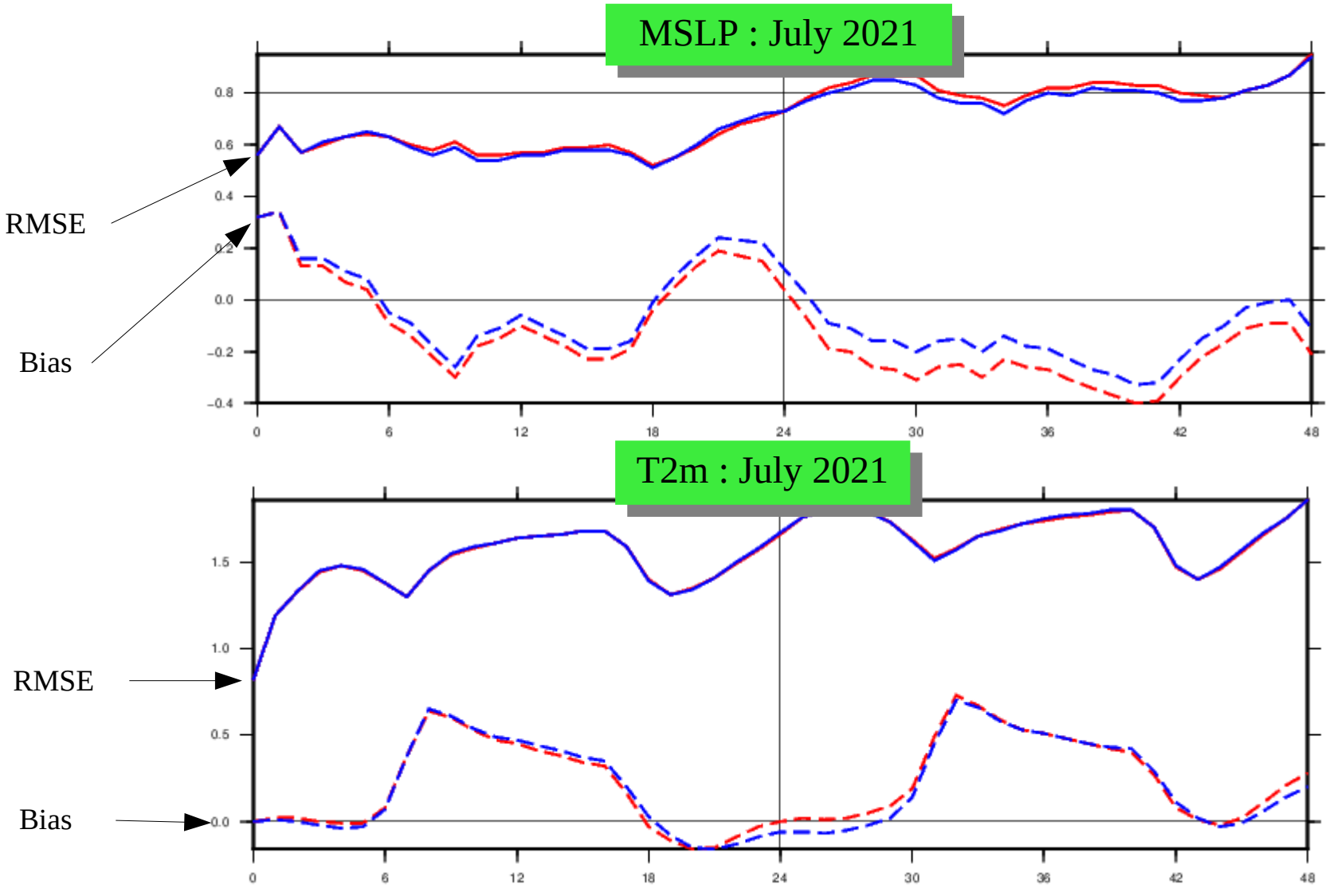


→ ecRad scores close to Oper, slight improvement

→ new optical properties also tested, little impact on scores (not shown)

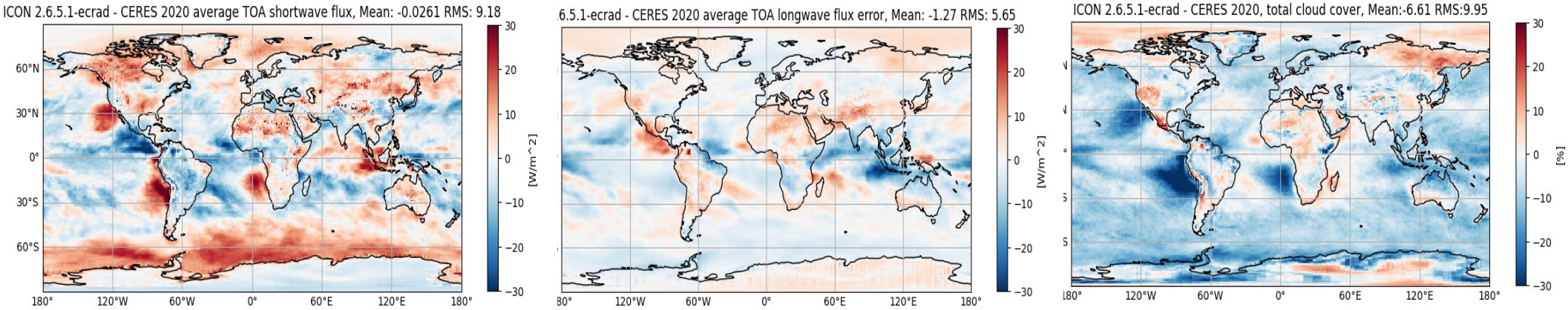
Aerosol impact : ecRad+CAMSAERO versus ecRad

- In ecRad : new aerosols climatologies available based on CAMS (in CY46T1 : 2D, in CY48T1 : 3D)



→ In July, improvements on surface pressure with CAMS Aerosols Clim

Research questions and challenges

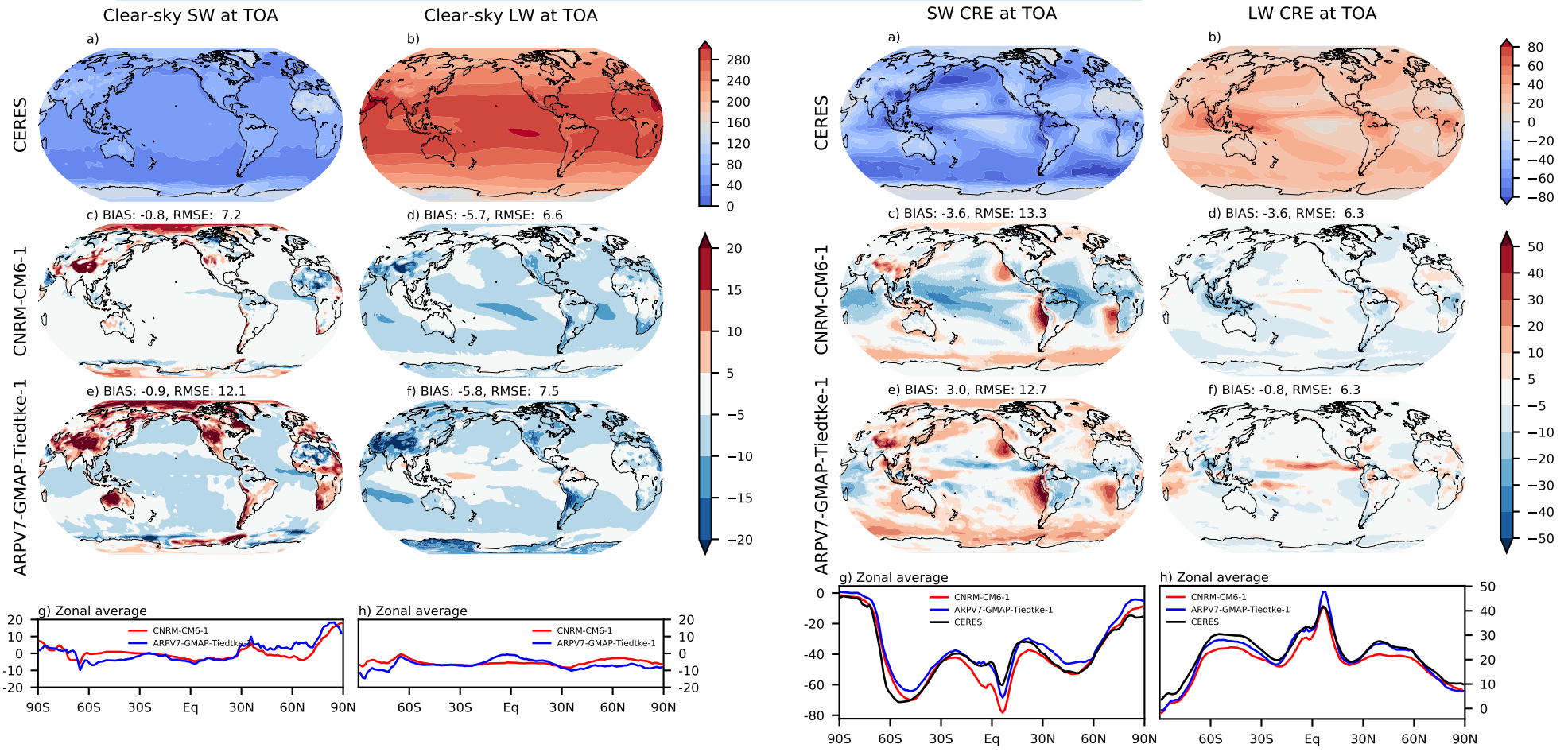


Biases in shortwave and longwave TOA radiation and cloud cover in ICON model vs. CERES satellite data (done at DWD)

- Global and local radiation balance / evaluation
- Cloud interactions, cloud cover, microphysics, cloud geometry
- 3D effects (clouds, surface)
- Sensitivity to radiation options
- Impact on physics and dynamics
- Aerosols, surface interactions

Looking forward to collaborations

First tests with ARPEGE-Climat (T. Drugé, R. Roehrig)



Errors in TOA clear-sky radation and cloud radiative effect (CRE) vs. CERES data (top) in shortwave and longwave for ARPEGE-Climat 6.3 (2nd line), ARPEGE-Climat 7 using ecRad (work in progress, 3rd line) and zonal averages (4th line). Plots by T. Drugé

- ecRad + new ARPEGE version increases clear-sky SW land – sea contrast / bias
- Clouds less reflective in SW with ecRad (esp. tropics), LW CRE overestimated for some tropical clouds
- Needs analysis / tuning.

Status and ideas 3D radiation

Possible to use / test in TeamX project (campaign Sept 2024 – Winter 2025/26)

SPARTACUS : Approximation of sub-grid 3D (now quite fast, needs cloud edge estimate, some issues in LW or single precision)

Existing resolved / inter-column 3D :

- Explicit raytracing / Monte Carlo :
  - Raytracing on GPUs (Uni Wageningen): expensive, implemented in MicroHH LES
  - Monte Carlo (H. Barker, Environment Canada)
  - At MF : Monte Carlo offline / coupled (N. Villefranque → MesoNH) : planned > 1 year
- Approximations :
  - (Dynamic) Ten-Stream (LMU Munich, in MicroHH, ICON?) : approximate 3D by iteratively transporting across limited number of columns
  - Layerwise diffusion (R.Hogan, ECMWF, ongoing) : tilted column + layerwise diffusion, test version, fortran implementation in ca 6 month to 1 year in ecRad

Summary

- Started work on new Meso-NH ecRad implementation + version update
- Météo-France ecRad repository exists (no content yet)
- Workflow for consistency in 3 models, easier in future
- Collaborations to evaluate ecRad in various models / settings
- 3D radiation: SPARTACUS : sub-grid 3D, ideas for explicit 3D

- Future: evaluation, optimisation of settings, consistency with other parametrisations
- Plan: Reduced radiation grid – implemented in Meso-NH (V. Masson), for AROME : ongoing work with Denmark Meteorological Institute,
  → Possibility to use SPARTACUS on larger columns for 3D

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