Planning for radiation in NGGPS

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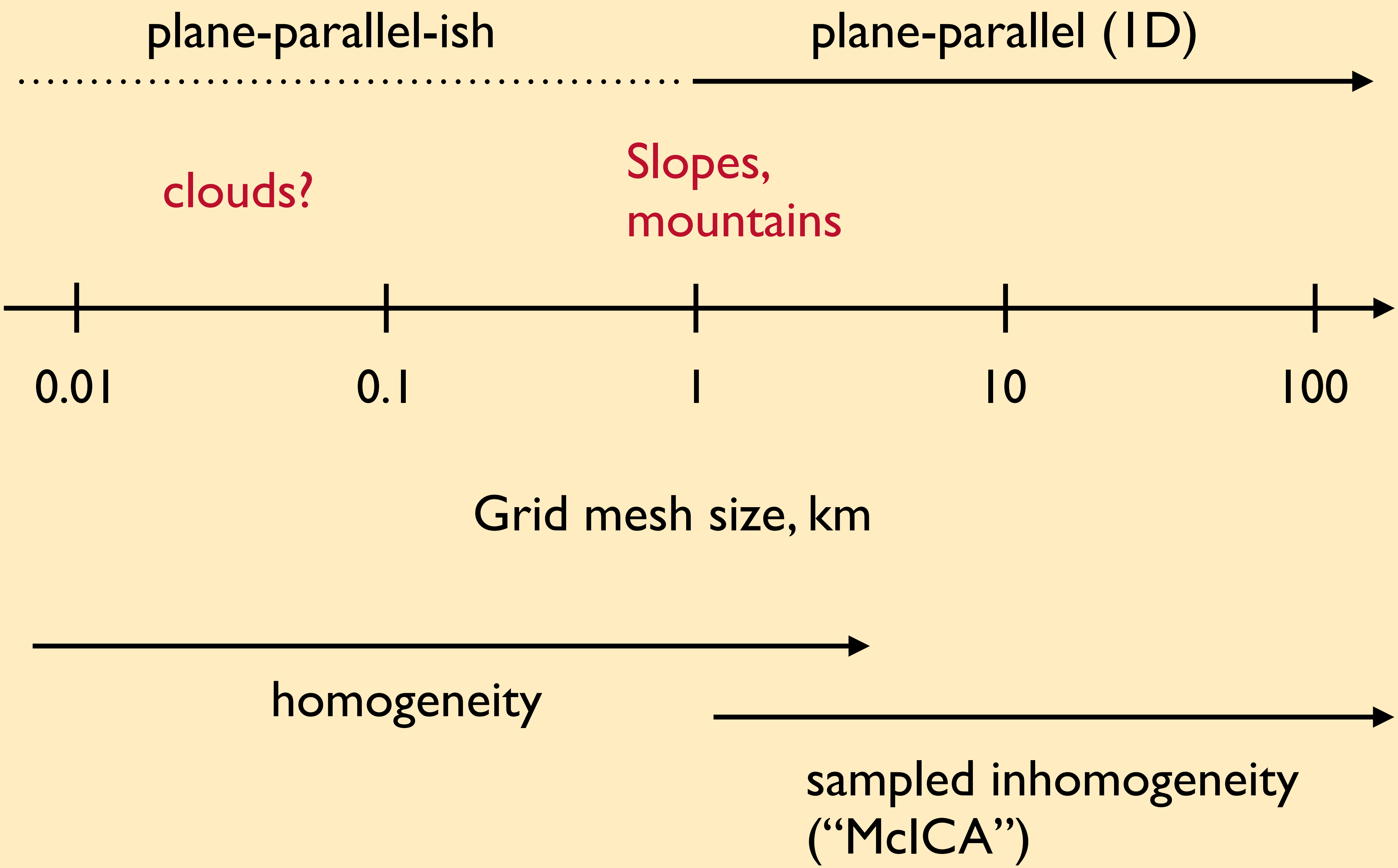
The same underlying (plane-parallel, homogenous) radiation model can be used for dynamical predictions across NGGPS-relevant scales

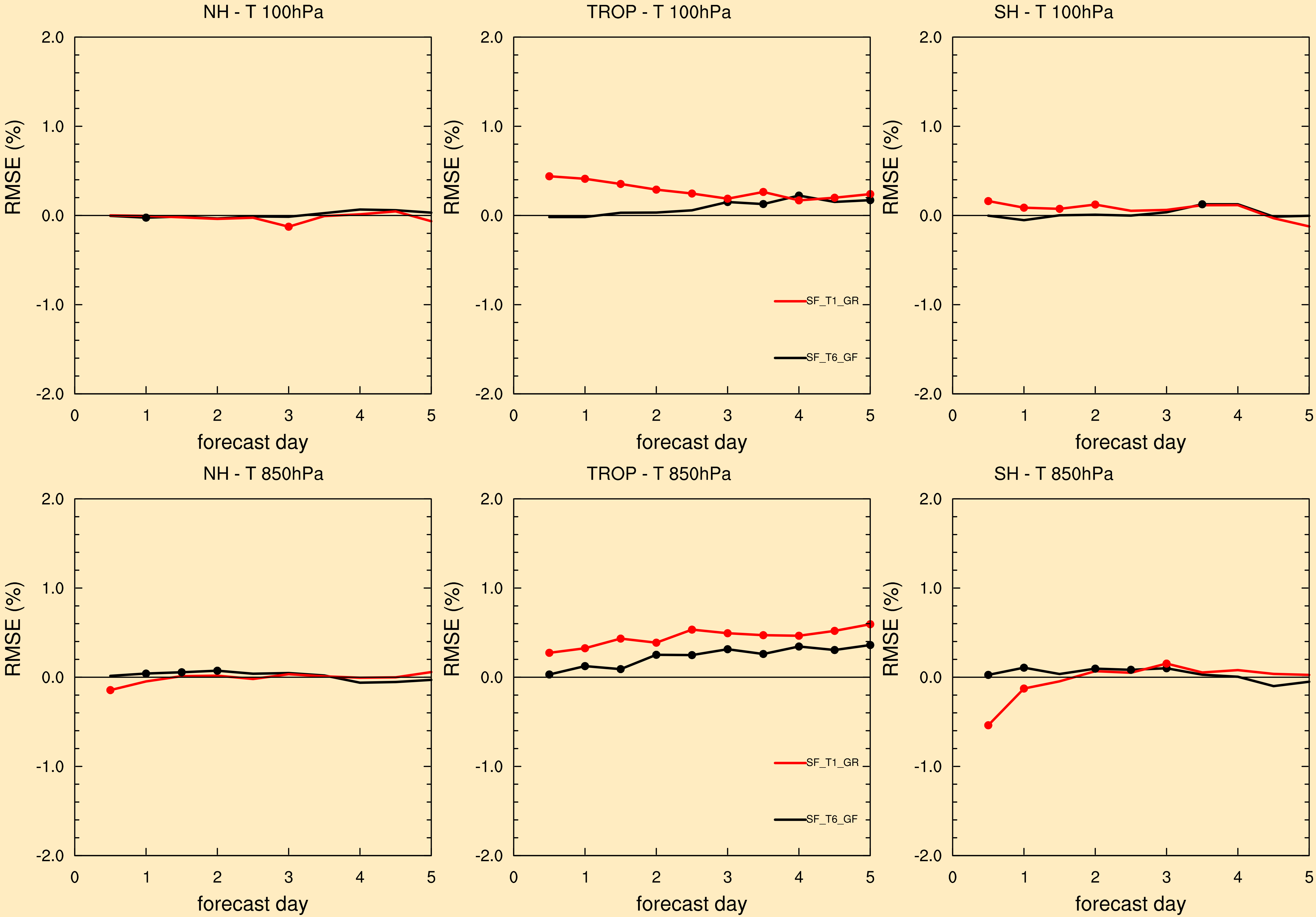


Radiation is computationally expensive

In operational configurations of GFS, radiation is called infrequently… (1 hr, compared to 7.5 minutes for dynamics and 3.75 min for physics)

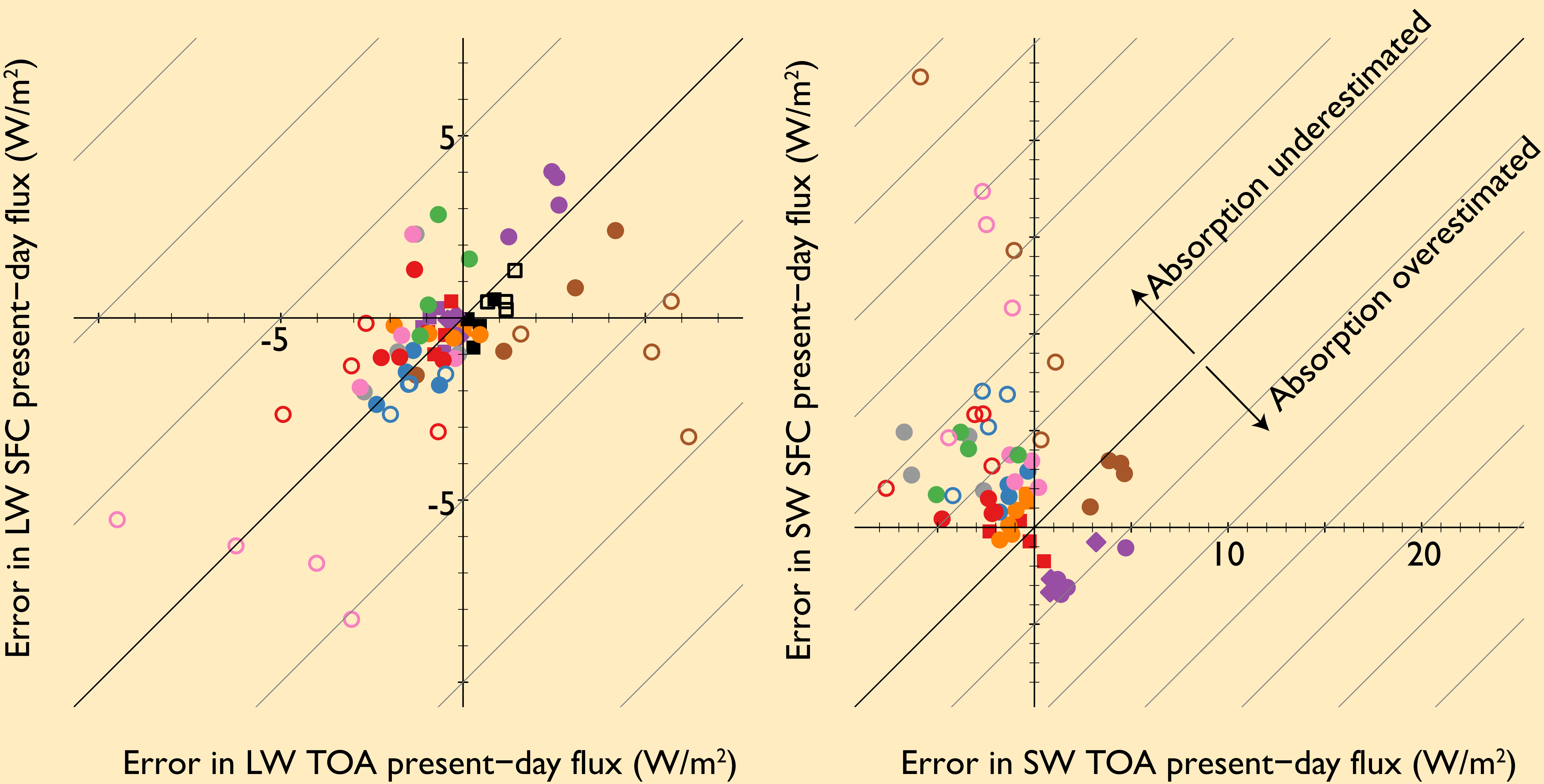
… but consumes 11% of the total model run time (compare to 60% for dynamics, 18% for all other physics)

Radiation doesn't offer lots of room for improving skill



Bozzo et al., doi:10.1002/2014MS000386

but there's plenty of room to make mistakes



Pincus et al. 2015, 10.1002/2015GL064291

What a radiation parameterization needs to do

Coupling: determine the spectrally-dependent optical state (optical thickness, single-scattering albedo, asymmetry parameter) of the atmosphere from its physical state

- Gases
- Clouds
- Aerosols
- (Land)

Determine layer properties (reflectance, transmittance)

Compute transport

Spectral integration/reduction and other diagnostics

What a radiation parameterization needs to do

Coupling: determine the spectrally-dependent optical state (optical thickness, single-scattering albedo, asymmetry parameter) of the atmosphere from its physical state

- Gases
- Clouds
  - Links to macro-physics (condensate PDF, "overlap") with McICA
  - Links to micro-physics
- Aerosols
  - Links to micro-physics
- (Land)

Determine layer properties (reflectance, transmittance)

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Spectral integration/reduction and other diagnostics

Which gas optics?

GFS is currently using the 20-year old RRTMG parameterization developed by AER

Modern, freely available alternatives are not many. The best is SOCRATES from the UK Met Office.

We agree that the RRTMG successor, RRTMGP, is the best path forward.

- It's close to the existing scheme but more accurate, more efficient, and more flexible in coupling to the host model
- Developers are responsive and can be entrained into efforts
- Coupling is via modern Fortran constructs so will require software engineering relative to GFS

Coupling to clouds

Macro-physics:

Present: simple description, coupling to be provided with RRTMGP

EDMF (Bretherton/Teixeira CPT): Much as at present(?)

SHOC+AW (Krueger/Randall/Pincus CPT): explicit macrophysics for both stratiform and convective clouds. Stratiform coupling is in progress under CPT; convective coupling in the pipeline

In all cases overlap prescription could be revisited

Microphysics:

Simple approach: use parameterizations supplied by AER (Mie theory for liquid; elaborate calculations with specified shape for ice)

More sophisticated: use information from GSM6 or MG microphysics to add interactions with new species (rains, snow) or treat changing size distributions. Impacts on radiative fluxes are likely to be small.

Coupling to aerosol

Much greater aerosol information will be available pending work by Sarah Lu's CPT, but these forecasts will be run separately.

Coupling for high-resolution model will be via files of optical properties. Small adjustments to existing code to deal with different spectral discretization are all that's needed

Planning and priorities

RRTMGP could be integrated in NGGPS today, although production would have to wait for new spectroscopy (Jan for LW, March? for SW)

Coupling to clouds for present representation, possibly EDMF requires software engineering but little else. Coupling to SHOC+AW part of existing CPT with implementation in NEMS. Even given working code coupling should receive some software engineering attention.

Aerosol coupling requires no conceptual development but some attention to generating, reading, and writing data.

Full integration could be initially accomplished in two or thee years.

These are priorities, not plans. We are not aware of any funding from NGGPS for radiation at NCEP or elsewhere