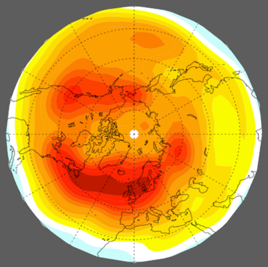


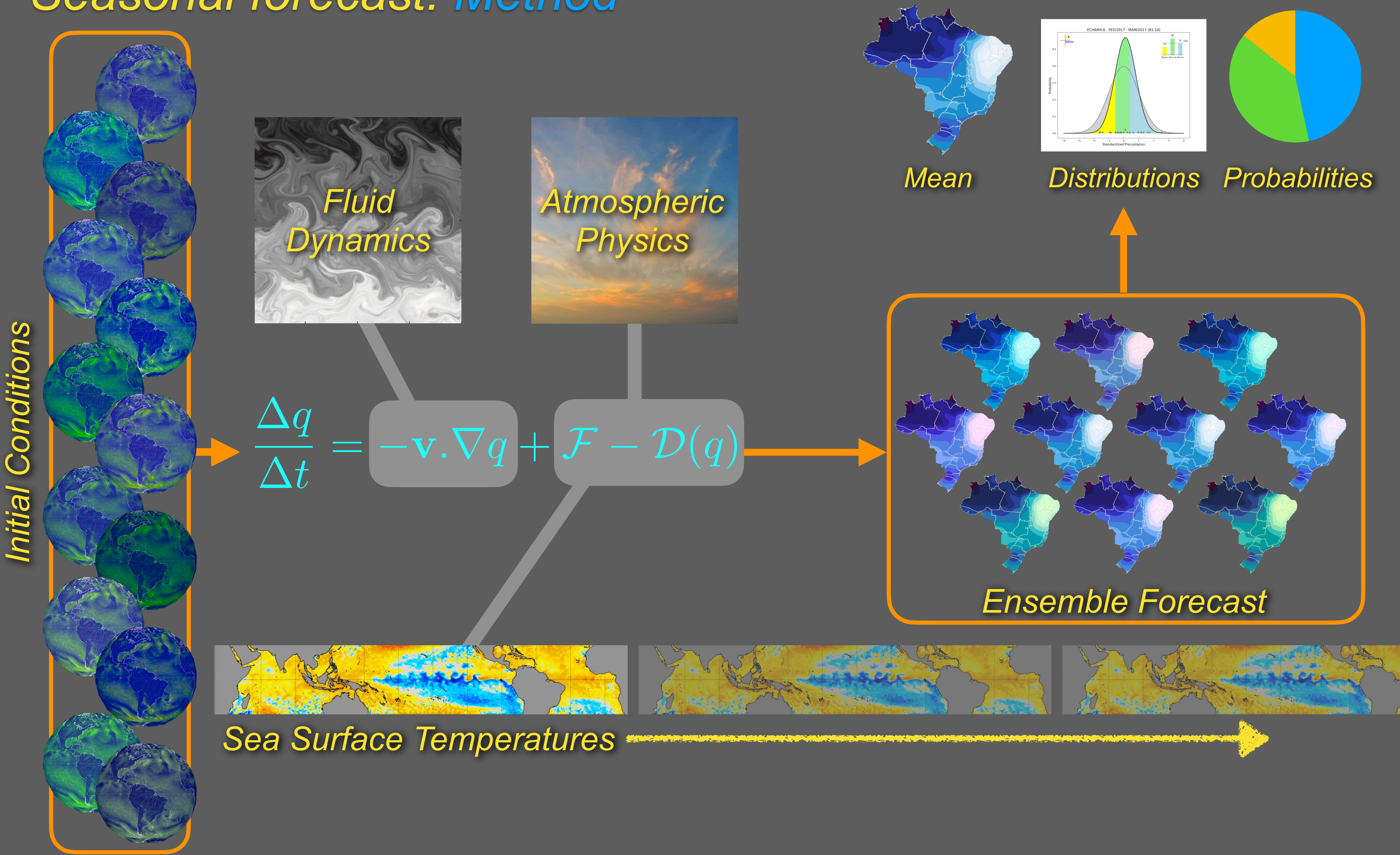
DREAM:
Dynamical Research Empirical Atmospheric Model

Two questions:

1) How to we replace the explicit physics in a global general circulation model with data-derived alternative ?

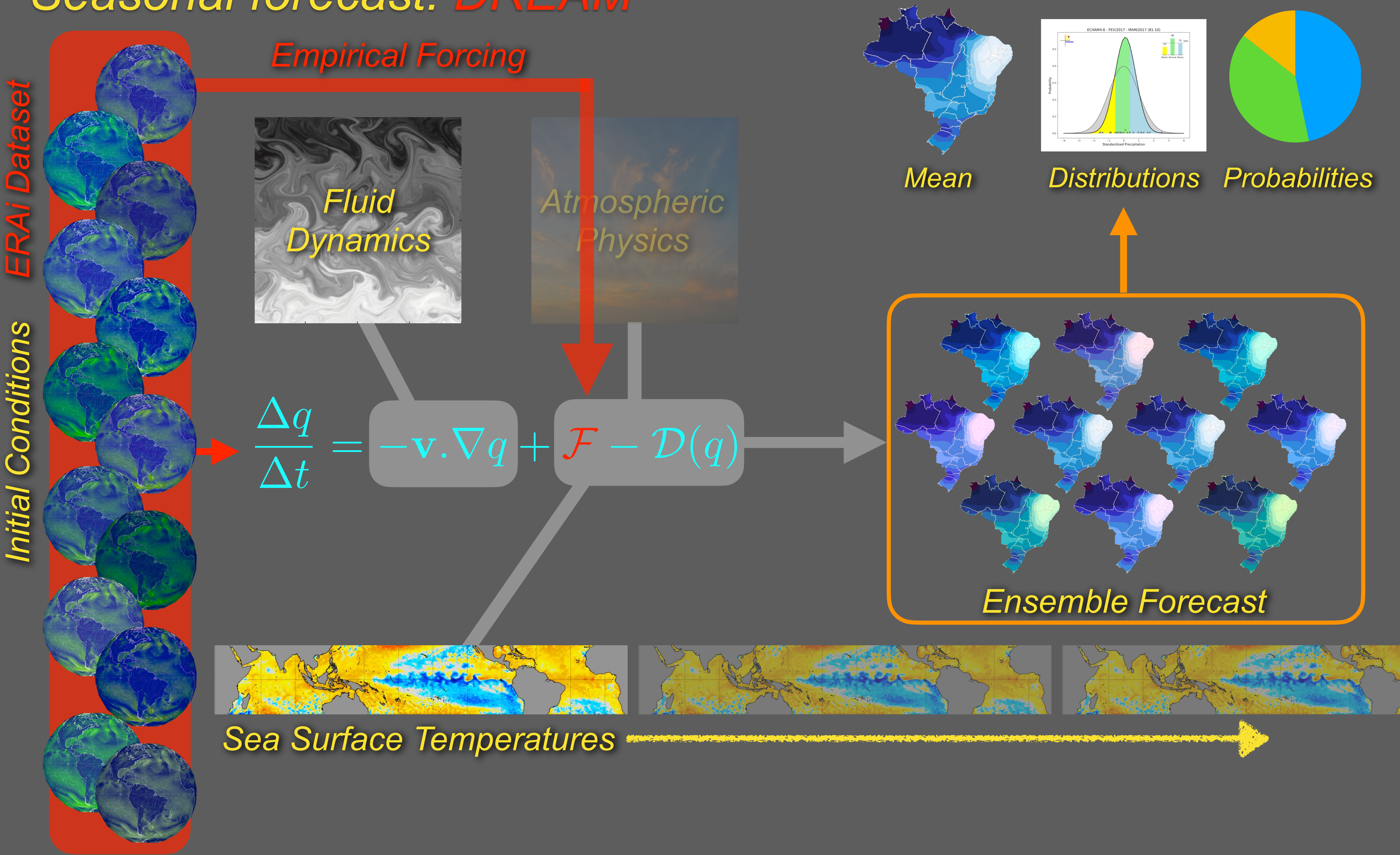
2) How do we represent the relationship between sea surface temperatures and precipitation over the ocean ?

Seasonal forecast: Method



ECHAM 4.6 Global GCM, Resolution T42L19. 20-member ensemble. RSM97 Regional Downscaling model.
One-month single member forecast: ~ ONE HOUR CPU (FUNCEME computer system)

Seasonal forecast: DREAM



DREAM Global Dynamical Model, Resolution T42L15. 38-member ensemble.

One-month single member forecast: ~ ONE MINUTE CPU (this laptop).

Empirical forcing philosophy

Consider the development of potential vorticity, q in the atmosphere:

$$\frac{\partial q}{\partial t} + \mathbf{v}.\nabla q = \mathcal{F}(t) - \mathcal{D}(q)$$

External Forcing

Make a model of this by assuming the external forcing is fixed

Let's construct a model of this.
The only thing external to our model is F
Substitute a forcing G deduced from data.

$$\frac{\partial q}{\partial t} + \mathbf{v}.\nabla q + Dq = \mathcal{G}$$

We can use the model to deduce the forcing G from a time series of reanalysis data.

We can calculate G by taking the average of a large number of single-timestep integrations of the unforced model

$$\mathcal{G} = \overline{\mathcal{F}} = \overline{\mathbf{v}.\nabla q} + D\overline{q}$$

$$= \frac{1}{n}\sum_{i=1}^{n} \mathbf{v}_i.\nabla q_i + Dq_i = -\frac{1}{n}\sum_{i=1}^{n} \left.\frac{\partial q_i}{\partial t}\right|_{uf}$$

Add the intelligence:

$$\mathcal{F}(t) \rightarrow \mathcal{F}(t,q) \quad \mathcal{G} \rightarrow \mathcal{G}(q)$$

Condensation and convection

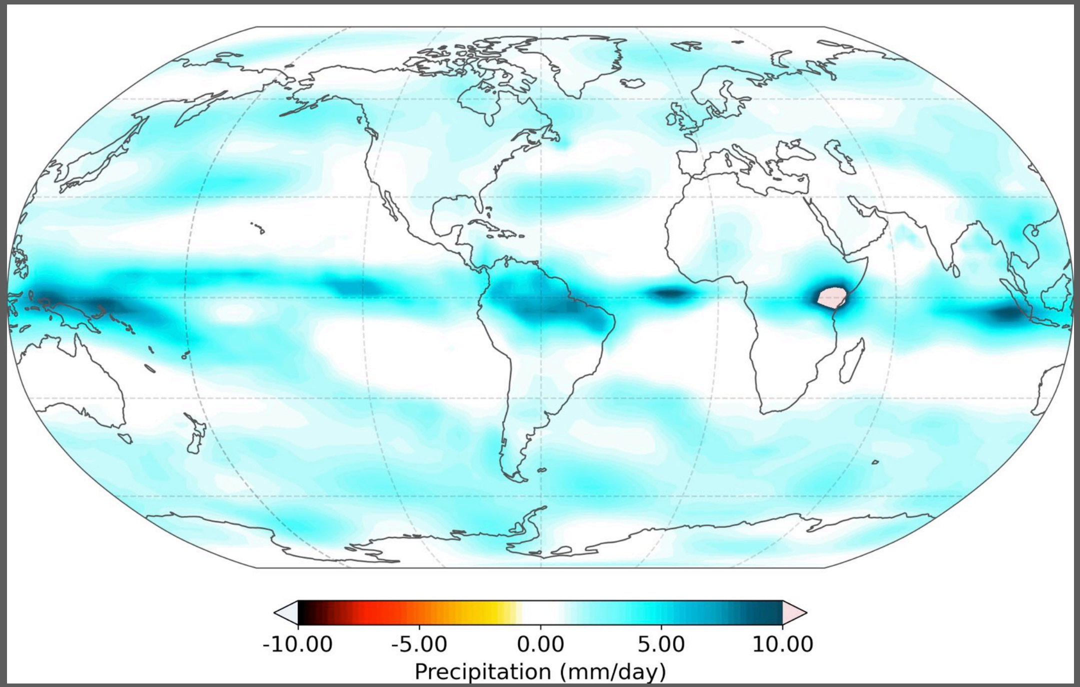
DREAM can be run as a dry GCM with moisture acting as a passive tracer.

DREAM can also be run with active schemes for large scale rain and deep convection.

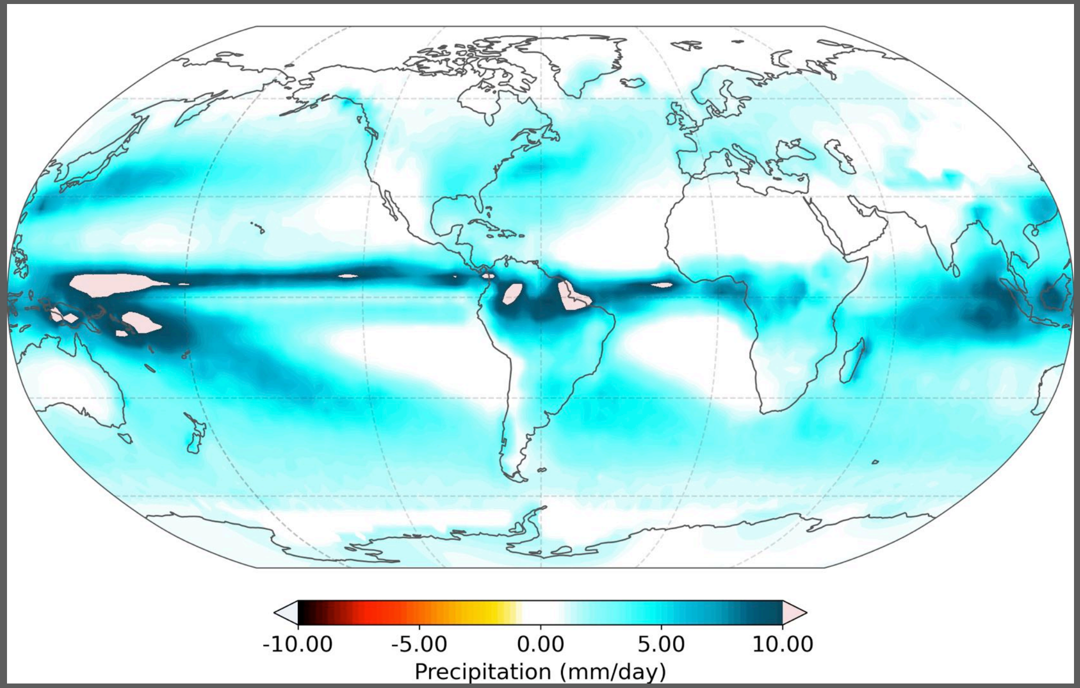
The deep convection interacts with the dynamics through condensation heating in the upper troposphere.

Prescribed SST anomalies are converted into fixed anomalies in precipitation, which are also linked to anomalies in deep tropospheric heating.

This deep heating drives a dynamical response in the atmosphere, which in turn influences changes in precipitation over the continents.



MAM Precipitation: DREAM



GPCP: 1991-2020

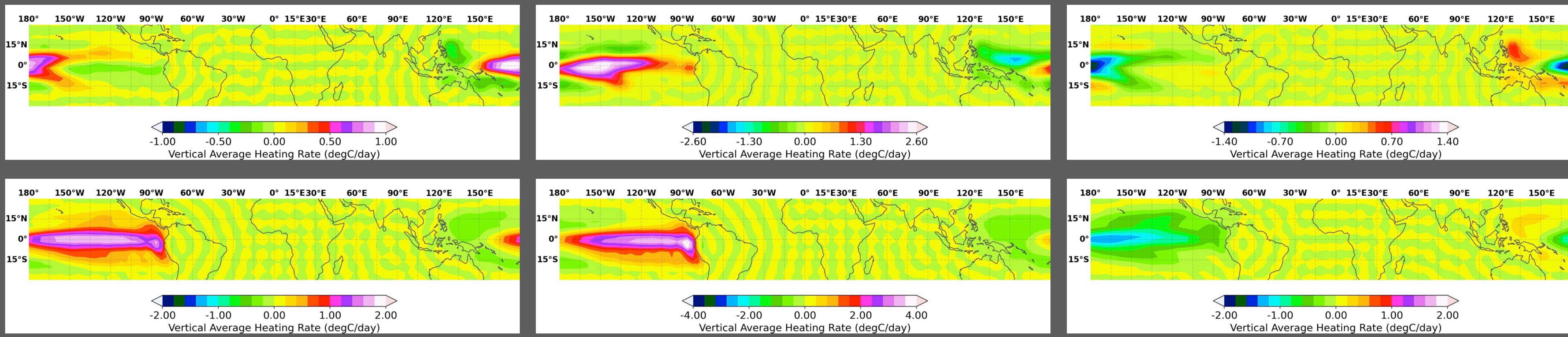
Precipitation climatology from DREAM provides a reasonable basis for anomaly forecast experiments

From SSTA to precipitation

MELN XELN LAN

PPT

linear



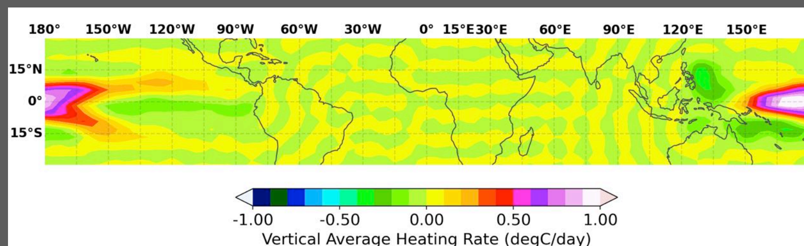
$$p' = M_{1FR}\, M_1\, e^{\beta_{FR}\beta(T_C - T_0)}(D_C - D_0)(e^{\beta T_A} - 1)$$

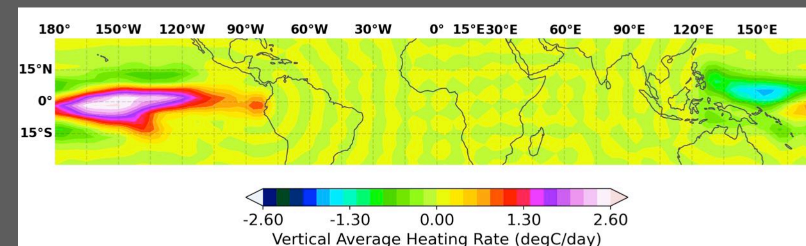
	RM1FR	beta	betaFR	Tref0	DIVref0
tuned by eye	0.25	0.28	2.0	25	10
MELN	0.15	0.48	2.25	27	11
XELN	0.20	0.47	1.25	26	18
LAN	0.45	0.21	2.75	26	17
compromise	0.2	0.4	2.5	26.8	15

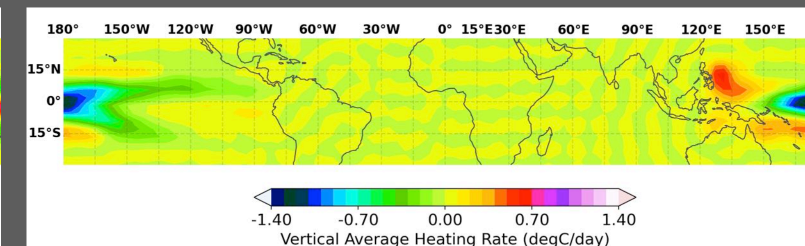
From SSTA to precipitation

MELN | XELN | LAN

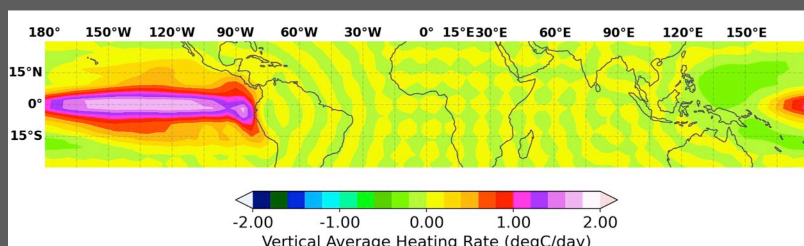
PPT

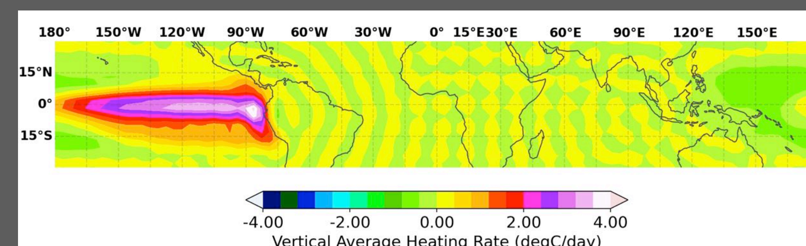


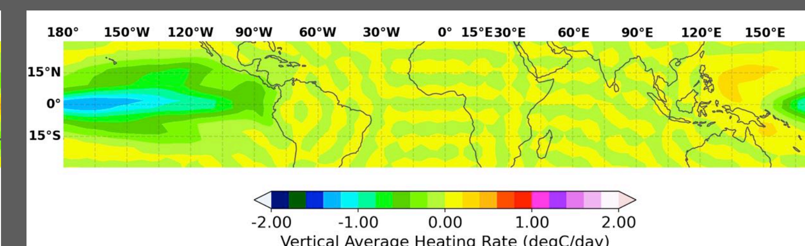




linear





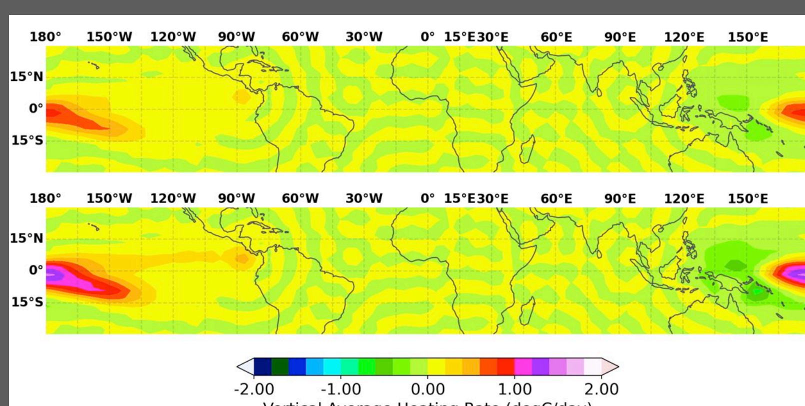


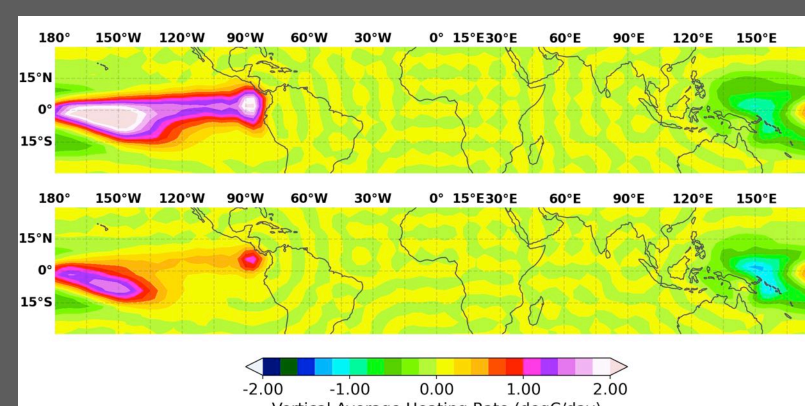
$$p' = M_{1FR}\, M_1\, e^{\beta_{FR}\beta(T_C - T_0)}(D_C - D_0)(e^{\beta T_A} - 1)$$

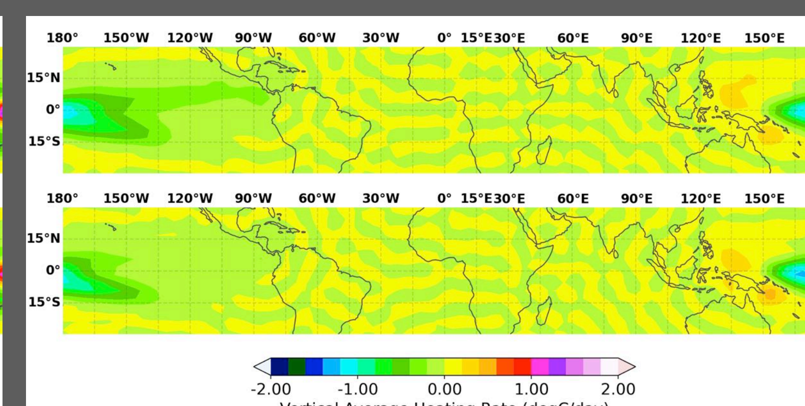
DJF

optimised

compromise







Can we make this more intelligent ?