Purpose of assimilation : reconstruct as accurately as possible the state of the atmosphere (the ocean, or whatever the system of interest is), using all available appropriate information. The latter essentially consists of

- The observations.
- The physical laws governing the system, available in practice in the form of a discretized, and necessarily approximate, numerical model.
- 'Asymptotic' properties of the flow, such as, *e. g.*, geostrophic balance of middle latitudes. Although they basically are necessary consequences of the physical laws which govern the flow, these properties can usefully be explicitly introduced in the assimilation process.

Both observations and 'model' are affected with some uncertainty $\Rightarrow$ uncertainty on the estimate.

For some reason, uncertainty is conveniently described by probability distributions (don't know too well why, but it works).

Assimilation is a problem in bayesian estimation.

Determine the conditional probability distribution for the state of the system, knowing everything we know (unambiguously defined if a prior probability distribution is defined; see Tarantola, 2005).

How to define in practice a probability distribution in a very large dimensional space ?

Only possible way seems to be through a finite ensemble, meant to sample the distribution.

⇒ *Ensemble methods* (used also for prediction)

Exist at present in two forms

- *Ensemble Kalman Filter* (*EnKF*). Still linear and Gaussian as concerns updating phase.

- *Particle filters.* Dimension !

Remarks.

- Ensembles must be evaluated, not only in terms of expectation, but also in terms of spread (as done for ensemble prediction). Relevant properties are *reliability* and *resolution*.

- Sequential assimilation (such as EnKF or particle filters) cannot taken temporal correlations into account.

Variational assimilation can (at least within assimilation window).

Q. Is it possible to have at the same time the advantages of both ensemble estimation and variational assimilation (propagation of information both forward and backward in time, and, more importantly, possibility to take temporal dependence into account) ?

Observability

What must one observe to know what ?

Dynamical ‘downscaling’

Q. Is it possible to determine the small scales of the motion from the observed history of the large scales ?