Physics of Atmospheres and Oceans - Class Question Sheets

Michaelmas Term: FURTHER REMOTE SOUNDING

In the ATSR problems (FRS.1–4), T_N and T_F are nadir and forward view brightness temperatures (linearizing $L(T)$ about a single reference temperature), T_S is surface brightness temperature and T_A the "atmospheric correction" term,

$$T_N = T_S + T_A$$
$$T_F = T_S + (\sec\Theta)T_A$$

where $\Theta = 55°$.

FRS.1 If the standard deviations of T_N and T_F due to measurement noise are both 0.1 K and the noise is uncorrelated, what is the optimal estimator for T_S and what is the standard error of this estimate?

FRS.2 If $T_N = 295$ K and $T_F = 287.5$ K, what is the best estimate of T_S? If $T_N = 279$ K and $T_F = 278.25$ K, what is the best estimate of T_S? What are the values for T_A in both cases? Comment on your result, where these observations might have been taken, and why the atmospheric corrections are very different.

FRS.3 If, because of thermal inertia for example, errors in T_N and T_S are found to be correlated with $\rho = 0.5$ (they aren't, but for the sake of argument) but with s.d.s still 0.1 K, what is the new optimal estimator for T_S and what is its standard error? Has it increased or decreased because of the correlation? Why?

FRS.4 Setting $\rho = 0$ again, suppose you have some additional information (from a weather forecast model, for example) that suggests that $T_A = -5$ K with a standard error of 0.5 K. If $T_N = 295$ K and $T_F = 287.5$ K, what is your new best estimated of T_S and what is its standard error?

FRS.5 Explain the terms *geostrophic balance* and *geoid* in the context of oceanography. Assume that the ocean consists of a single active layer in geostrophic balance overlying a deep, inert abyss. An altimeter records sea-surface height η relative to the geoid. Show that the across-track geostrophic current u_c is given by

$$u_c = \frac{g}{f}\frac{\partial\eta}{\partial r}\,,$$

where r is the along-track distance.

A radar altimeter on a satellite records a local value of η which increases at 50 cm per 100 km at 45° latitude. Calculate and sketch u_c and give its orientation. Assuming mean densities in the active layer are 0.2% lower than in the abyss, what is the along-track slope of the thermocline?

In the course of a month, ten overpasses at three-day intervals of a location at 45° N, all inclined at 105° to the equator (i.e. southeast to northwest) give a mean η decreasing at

50 cm per 100 km. Ten further overpasses of the same point on the same days inclined at $-105°$ (northeast to southwest) give a mean η increasing at 10 cm per 100 km. Estimate the zonal and meridional components of the mean geostrophic current.

The standard deviations of both sets of individual measurements relative to their monthly means are 50 cm per 100 km, and departures from the monthly mean have a correlated coefficient of 0.5. Calculate the resulting standard errors of your estimates of the components of the monthly mean geostrophic currents.You may assume errors are Gaussian and measurements made on different days are mutually independent.

[11.08]